Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

CIRCULAR No. 499 NOVEMBER 1938
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

# A COMPARATIVE STUDY OF SUITABILITY FOR DRYING PURPOSES IN FORTY VARIETIES OF THE SWEETPOTATO

By Joseph S. Caldwell, *senior physiologist*, Hubert H. Moon, *assistant pomologist*, and Charles W. Culpepper, *physiologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

## CONTENTS

Page
Introduction 1
Earlier studies of the utilization of the sweetpotato 1
Methods and results of experiments 4
  Forms of dried product produced 5
  Preparation of dehydrated sweetpotato in slice or strip form 6
  Preparation of granulated or riced sweetpotato 17
Drying 18
  Types of driers employed 18
  Temperatures employed in drying 20
  End point of the drying process 22
  Packing and storage of the dried product 24
  Yield of dry product obtained 25
Comparative studies of the dried products 28
  Methods employed in preparing material for comparisons of table quality 29
  Grading of color and appearance of the dry material 31
Comparative suitability of varieties for drying purposes 34
  Varieties considered suitable or desirable 34
  Varieties not suitable or promising 39
  Group relationships in relation to varietal quality 41
  Disease resistance as a factor in choice of varieties 46
Summary 47
Literature cited 49

## INTRODUCTION

The extensive cultivation of the sweetpotato in the United States, its high food value, and the considerable portion of the crop which is annually lost through absence of means for its preservation are sufficient justification of rather thorough investigation of possible means for more effective utilization of the crop, either by direct manufacture into food products or as raw material for industrial purposes. An adequate foundation for such studies is supplied by the numerous investigations of the developmental and storage physiology of the roots (*2*, *16*, *20*, *21*, *22*, *23*, *24*, *29*, *35*, *39*, *40*, *44*)[1] and of the physical and chemical changes occurring during the curing process (*6*, *10*, *22*, *26*).

## EARLIER STUDIES OF THE UTILIZATION OF THE SWEETPOTATO

Long continued cultivation of the sweetpotato in Japan has resulted in the development by that people of a number of methods of utilizing the crop. Manufacture of starch from the sweetpotato has long been practiced, and has grown from a household practice into an industry of considerable magnitude employing at least in part varieties selected or developed specifically for the purpose (*1*, *49*). Sweetpotatoes are also rather extensively used in the manufacture of alcohol in Japan, and a considerable portion of the material so used is previously dried in order to extend the working season of the alcohol plants as well as to decrease transportation costs. Dried sweetpotatoes, known as sen, are rather extensively employed as human food, especially in Taiwan.

---

[1] Italic numbers in parentheses refer to Literature Cited, p. 49.

Shiver (*39*), working at the South Carolina Agricultural Experiment Station, appears to have been the first American worker to realize the possibilities of the sweetpotato as a source of starch. His first publication on the subject appeared in 1897, and the series of studies thus begun was continued in various publications of Shiver, Keitt, and their associates in the station over a period of 15 years (*27*, *28*, *29*, *30*, *36*, *40*, *41*). Among these, that of McDonnell (*30*) described in detail a method for the extraction of starch from the roots and gave results for comparison with various other starches for industrial uses.

McDonnell's methods of extraction were rather imperfect and there were very considerable losses of starch in the process. No commercial development resulted from his work, but his studies and those of his associates called attention to the rather wide differences in starch content between varieties at digging time and to the resulting differences in value of the raw material for starch-making purposes.

More recently, the Bureau of Chemistry and Soils of the United States Department of Agriculture has taken up the problem of developing efficient methods of manufacture of starch from the sweetpotato, and a series of studies reported by Balch and Paine (*1*), Thurber (*47*, *48*), and Thurber and Paine (*49*) have reported development of improvements in the technique of manufacture, which combine a higher degree of extraction of the starch from the raw material with satisfactory methods of removal of carotinoids and other impurities from the starch.

Gore (*11*, *12*, *13*, *14*) devoted considerable attention to the development of a process of making table sirup from sweetpotatoes in which the starch of the potatoes, after previous cooking and pulping, was hydrolyzed by malt extract. The process was subsequently found to be essentially similar to one upon which Charles Delamarre, of New Orleans, had been granted United States Patent No. 109991 in 1870. In later work Gore (*13*) found that the addition of malt or malt extract to the pulped potatoes was unnecessary, since sweetpotatoes are so rich in diastase that practically all the starch is converted into dextrin and maltose during slow cooking. This confirmed the results reported by Magoon and Culpepper (*31*) from their studies of the changes occurring in canning, and has recently been again confirmed by Shuey (*43*). Costs of manufacture of Gore's sirup as compared with those of making other sirups already on the market and limitations of use, because of the characteristic taste of sweetpotato sirup, have thus far prevented any general commercial utilization of Gore's work. Shuey has recently described a method of making a jelly from sweetpotatoes (*42*).

Mangels and Prescott (*33*) prepared a sweetpotato flour for use in bread or in the making of pies by a modification of the "flake" process employed in the making of flour from white potatoes. The potatoes were cooked by steam under pressure, then pulped, the pulp was rapidly dried by spreading in a thin film upon internally heated rotating drums, and the continuous sheet thus obtained was scraped off and ground into flour. The workers were not able to control discoloration in the product, and the yields from the raw stock were low. The potatoes employed in their experiments had been cured prior to use, hence were high in dextrin, and the flour was so strongly hygroscopic that it could be stored only in airtight containers.

Magoon and Culpepper (*6*, *31*, *32*) carried out rather comprehensive studies of the canning quality of sweetpotatoes, employing 44 varieties and strains. In the course of their work they investigated many of the problems of the physiological behavior of the root. Chemical analyses, accompanied by canning tests, were made upon the material immediately after digging and also after the usual curing and storage. Their results showed very large differences in plasticity of the canned products made from freshly dug and cured stock of the same variety and large varietal differences in such characters as peeling quality, percentage of waste in preparation, tendency to discoloration and darkening on exposure to air, and table quality of the canned product when made into sliced and sautéed potato, candied potato, or pie stock. The chemical studies accompanying the cooking and canning tests showed in detail the composition of both raw and cooked stock of each variety immediately after digging and after curing and storage.

These workers considerably expanded existing knowledge of the physiological changes occurring in the roots during curing and storage and in the processes of cooking and canning. From the practical viewpoint they emphasized the fact that the chemical transformations occurring in the roots during curing and storage are so extensive and profound that the products made by identical methods from the same variety before and after curing are widely different in composition and consequently in appearance, texture, and flavor.

Drying of sweetpotatoes on a small scale for household use was rather widely practiced in the Southern States prior to the development of modern methods of storing the crop, and the older literature contains descriptions of a number of methods of drying the roots and employing the dried potatoes (*4*, *15*, *34*, *36*). Attempts to commercialize dehydrated products of the potato have been made at various times, some of which have been described by Gore, Reese, and Reed (*14*) or by Hand and Cockerham (*15*). None of these met with any degree of success in building up a consumer demand or establishing a permanent industry. A number of factors appear to have contributed to this result. Among these, direct competition with fresh potatoes as a result of improvement in methods of storage and distribution, which make the fresh product available over most of the year, has played a considerable part, as has the production of a canned product of improved appearance and quality. Factors influencing the character and quality of the dried product have also played a prominent if not decisive role in the failure of some of these undertakings by making the competition with fresh or canned sweetpotatoes an unequal one. Some of these factors are use of raw material of poor quality or of varieties unsuited to the purpose, failure to control discoloration and other undesirable changes in the material during drying, hygroscopic character and consequent perishable nature of the product, requiring special forms of package, and production in forms having only limited usefulness in cooking.

Johnson (*25*), working at the Hawaii Agricultural Experiment Station, developed methods of drying sweetpotatoes, taro, cassava, and edible canna. His purpose was primarily the making of flours for use as wheat-flour substitutes, but he also prepared a boiled and sliced dried sweetpotato for table use. Analysis of this product showed 11.43 percent of moisture, 77.09 of nitrogen-free extract, 6.12 of crude protein, 0.55 of ether extract, 2.16 of crude fiber, and 2.65 percent of ash, the yield approximating 28 pounds per 100 pounds of fresh sweetpotatoes. Interest in Johnson's work in Hawaii seems to have declined with the passing of the temporary shortage of wheat-flour supplies which was responsible for it.

## METHODS AND RESULTS OF EXPERIMENTS

The purpose of the present work was twofold: (1) To develop a method for the dehydration of the sweetpotato that should yield a product of attractive appearance and acceptable quality, capable of being prepared for the table in a variety of ways, and sufficiently resistant to atmospheric conditions to permit storage and distribution without special precautions against spoilage, and (2) to examine systematically all the varieties and strains of the sweetpotato obtainable with respect to their suitability for drying purposes and the quality of the dehydrated product made from them.

The major portion of the experimental work herein reported was carried out in 1918 to 1923, concurrently with the work of Magoon and Culpepper upon the canning of sweetpotatoes (*6*, *31*, *32*), and in the same laboratory. The material used was obtained from the same varietal collection employed by these workers, and in a great many instances portions of the same lot were used in the canning and drying experiments. In consequence, the analytical data upon raw and cured stock published by Magoon and Culpepper apply equally to the material used in these studies, and reference to their figures will be made where pertinent.

In the earlier experimental work, attention was devoted primarily to developing a method of drying that would yield a product of satisfactory appearance and table quality and of nonperishable character under ordinary storage conditions. The material used for this purpose was confined to a few commercially important varieties which were available in quantity and which at the same time fairly represented the range of variation to be found in sweetpotatoes in such characters as color and consistency of flesh, flavor, and culinary quality, and susceptibility to discoloration in cooking. These varieties included Nancy Hall, Porto Rico, Big Stem Jersey, Yellow Jersey, Southern Queen, Red Bermuda, and Triumph.

Later, when it was felt that a satisfactory general method of preparing and drying the material had been worked out, a comprehensive study of all the varieties and strains available, with special reference to their suitability to drying purposes, was undertaken. The plan of work contemplated preparation of the dry product from each of the varieties in some quantity immediately after digging and also after curing and storage for various intervals, the storage of the dried products under a variety of conditions for considerable periods, and the making of comprehensive tests of appearance, quality, and flavor of various cooked products prepared from the material. The tests were to be continued over several years, in order to obtain some idea of the extent to which varying seasonal conditions might affect the behavior of the raw material and the quality of the products.

Circumstances compelled the interruption of the work until 1934, at which time material of 13 important commercial varieties and 9 unnamed selections was available. The earlier work upon methods of preparation and drying was repeated and extended upon this material, and the earlier conclusions as to varietal suitability were rechecked. The general methods employed in the earlier and the later work were essentially the same, and the results with those varieties used throughout were so closely identical that no hesitation is felt in considering the two portions of the work as a whole.

The total number of varieties and strains studied in the course of the work is approximately 70. A group of about 25, including all the more widely grown commercial varieties, a few especially promising recent introductions, and representatives of all the important American varietal groups (*46*) was employed year by year throughout the work. A second group consisted of less generally grown minor varieties of fairly wide distribution, some of which are fairly important in certain districts, and included a number of more or less distinct strains derived from some of the more widely known or standard varieties. Work with each of these was continued long enough to determine its possibilities for drying purposes as compared with the standard varieties. An attempt was made to secure as many of the distinct varieties actually in cultivation as possible. The results obtained with all the named varieties and strains are presented in the subsequent sections.

A third group tested was made up of unnamed varieties and strains of various origins, which were included in order to determine whether they had sufficient promise to warrant introduction. A number of these were being employed by Culpepper and Magoon (*6*, *31*) in their studies of canning quality. By far the larger number of the unnamed varieties were found by the field tests to be distinctly inferior to existing cultivated varieties and were consequently dropped from the collection.

## FORMS OF DRIED PRODUCT PRODUCED

At the outset of the work, experimental lots of material were prepared for drying in a considerable variety of forms, including longitudinal and transverse slices of various thicknesses, halves, quarters, or strips of various sizes, dice or cubes, and in a granulated or riced form. Fairly satisfactory products were ultimately obtained in all these forms, but there were very wide differences between the various products in the amount of labor involved in their preparation, degree of difficulty encountered in controlling discoloration in drying and absorption of moisture and deterioration or spoilage in storage, and in the range of usefulness of the product in preparing dishes for the table.

Comparison of the various products with respect to all these factors led to attempts to produce a satisfactory product in one of two forms—as a granulated or riced sweetpotato or as transverse or longitudinal slices. A granulated product of satisfactory appearance and flavor was produced, but the process was more laborious than the making of slices or strips, the control of discoloration was more difficult, the product was bulky and rather strongly hygroscopic, requiring sealed containers for storage, and it could be prepared for the table in only two or three forms. The making of a granulated product was consequently discontinued after the first year or two of work. However, the methods employed and the difficulties encountered in its production are briefly described on page 17.

## PREPARATION OF DEHYDRATED SWEETPOTATO IN SLICE OR STRIP FORM

In all the later work and in the comparative studies, the material was prepared for drying by splitting the sweetpotato longitudinally into strips that were triangular in cross section and about two-thirds to three-fourths inch thick, or by cutting into transverse or longitudinal slices about one-fourth inch in thickness. This form of product was decided upon chiefly because of the variety of ways in which it could be prepared for the table.

### WASHING AND GRADING

Practically all the material used in the work was ungraded stock delivered to the laboratory just as it came from the field. It was washed by emptying the sweetpotatoes from the crates into a large tank of running water, agitating to loosen adhering dirt, and completing the cleaning by the use of a brush when necessary. Whether grading for size was necessary depended upon the variety. Some varieties, such as those of the Jersey group, are sufficiently uniform in size and shape, and no sorting for size was necessary; others, such as Porto Rico, Yellow Strasburg, and Pierson, vary so much that they were graded into two or three sizes. The decreased waste in peeling and the greater uniformity in cooking justified the labor of grading with such varieties. As a part of the washing and sorting process, the roots were closely inspected for indications of disease or decay.

### PEELING

Several different methods of peeling were used in an attempt to find one that would combine rapid and effective removal of the skin with minimum loss of edible material while leaving the roots in the best condition for the subsequent treatments. These may be briefly mentioned and their advantages and disadvantages indicated.

#### PEELING BY STEAMING OR BOILING IN WATER

Magoon and Culpepper (*6, 31, 32*) peeled the material used in their experiments by boiling in water or by spreading on trays and exposing to live steam in a steam box, usually until the sweetpotatoes were completely cooked, after which the peels were slipped off by hand. Their average losses in peeling by this method for 36 varieties were 13.8 percent for freshly dug stock and 18 percent for that previously cured and stored for 1 month.

In the present work, steaming for 10 to 15 minutes or longer permitted ready removal of the peels with little loss of edible material, but had the disadvantage that the sweetpotatoes were considerably softened, particularly at the tips, and that much breaking and crushing occurred in the subsequent slicing. The slices tended to adhere in masses, making proper spreading on trays for drying somewhat difficult, and there was considerable loss of material during drying as a result of sifting of fragments through the trays. The crushed, ragged appearance of the dried product also made it somewhat unattractive. It was consequently considered desirable to employ some method of peeling that would leave the potatoes firm until after they had been sliced and spread on the trays.

### PEELING WITH LYE

A 2-percent solution of commercial concentrated lye (caustic soda or caustic potash) kept at boiling temperature was very effective in removing the peels when the treatment was properly controlled. In these experiments the lye solution was made up in an enameled tank heated by closed steam coils in the bottom, the size of the tank and the depth of the solution being such that actual boiling of the liquid was not stopped when a crate of sweetpotatoes was submerged in the tank.

Ordinary bushel crates of the collapsible slat type or galvanized wire baskets of like capacity provided with wooden tops to keep the roots beneath the lye and with handles to facilitate handling were used as dipping vessels. The time required for loosening the peels varied somewhat with the variety and was somewhat increased after curing and storage as a result of thickening of the periderm, but was readily determined for any particular lot by observing the degree of splitting and loosening of the skins occurring as the potatoes were stirred by rotating the crate. As a routine procedure, submerging for 10 minutes gave very good results for most varieties. Varieties having small fusiform or spindle-shaped roots, such as those of the Jersey group, required somewhat shorter treatment than large-rooted varieties, such as Porto Rico, Nancy Hall, and Southern Queen. The potatoes were lifted directly from the lye bath into a tank of running water and stirred by rotating the crate while a jet of water played upon them. This loosened and removed most of the peels; portions adhering could be readily removed by hand.

There is practically no loss of edible material when the lye-peeling process is properly carried out, as the lye penetrates the storage parenchyma beneath the cortex only to the extent of 2 or 3 mm. This very thin layer softens and gelatinizes, loosening the cortex and permitting it to be slipped off bodily.

This method has the very great advantage that sweetpotatoes of irregular shape or those with prominent veins are peeled as readily and with as little loss of flesh as those of smooth, uniform shape.

The use of a knife to complete the peeling is rarely necessary with good, freshly dug stock. With stock which has been cured and held in storage for some time some knife work is necessary, as the cortex of the shriveled tips and that about healed cuts or bruises does not always loosen under lye treatment. A few varieties offer an additional difficulty because of the presence of numerous lateral roots that emerge at the bottom of more or less pronounced longitudinal grooves. These lateral roots hold strips of the loosened cortex in place, requiring removal by hand. The variety Miles "yam" was quite troublesome in this respect.

### PEELING BY ABRADING MACHINE

A rotary abrading or peeling machine of 1-bushel capacity having carborundum-lined sides and bottom was very efficient for peeling sweetpotatoes of fairly uniform size and smooth spindle or fusiform shape, such as most members of the Jersey group. These required very little hand trimming and there was little loss of edible material. With globular, irregular varieties, such as Porto Rico, those having pronounced ribbing, as Red Bermuda or Pierson, or those of long, crooked form, such as Key West "yam" and Dahomey, the removal of peels was very imperfect, requiring much hand trimming, and there was very considerable loss of edible material. Sweetpotatoes varying widely in size could not be peeled together, as the larger ones forced the smaller ones against the abrasive surfaces and held them there until they were completely worn away. Loss in machine peeling was somewhat greater after curing and storage and increased slowly with length of time in storage, chiefly because the peel was less readily abraded after curing, and longer time in the machine was necessary to remove it.

### LYE DIPPING COMBINED WITH MACHINE PEELING

A few experiments were made in which dipping in boiling lye to loosen the peels was followed by passing the sweetpotatoes through the abrading machine to remove them. These were not wholly successful, for when lye dipping was continued long enough to loosen the peel it tended to strip off in large pieces, or almost entire, and to mass together in lumps which resisted abrasion and choked the outlet of the machine. Flooding the machine with water did not wholly overcome the difficulty, as the gummy masses adhered to the sides and bottom and were only slowly loosened and washed out. Reducing the time in the lye bath decreased the gumminess of the peels, but left some areas still tightly attached, necessitating hand trimming or longer treatment in the machine with resulting increase in loss of material. The difficulties met with are inherent in the construction of rotary peeling machines, which are designed to abrade firm, resistant surfaces and which cannot satisfactorily handle a cortex that slips off bodily or is soft and gummy in character.

### CHOICE OF A METHOD OF PEELING

It is obvious from the foregoing that choice of a method would lie between lye peeling and the use of an abrasive machine and might be decided in any given case by the character of the stock to be handled. If the sweetpotatoes to be used were of the smooth cylindrical or fusiform type and fairly uniform in size, as in most members of the Jersey group, an abrasive machine might advantageously be used, as the work would be done rapidly with little loss of edible material and with a relatively small amount of hand trimming. If varieties of decidedly irregular size and shape were used, as in the Porto Rico, lye peeling would be preferable, for waste and hand labor would be held to a minimum while all sizes and shapes of stock from jumbos to strings would be peeled with equal efficiency.

The scale of the present work has not permitted an effort to mechanize the lye-peeling process, but it should be readily possible to do so by the use of a rotary lye dipper of the peach-peeler type in connection with a squirrel-cage washer provided with brushes and water sprays. If provided with an ample water supply under pressure, such a washing device would effectively break up and remove the peels without being subject to the clogging which occurred in the abrading machine when used to peel lye-dipped stock.

### LOSSES IN PEELING AND TRIMMING

Table 1 brings together all the data upon losses in peeling and trimming, both by lye and machine methods and with uncured and cured and stored stock for 39 varieties and strains. In most cases the figure given is an average obtained from a number of lots of roots from crops of several years, hence includes stock varying rather widely in condition. Also, lots of many varieties too small to be marketable were occasionally included in the samples. An attempt was made to avoid inclusion of decayed sweetpotatoes in the peelings and trimmings, but this was not always successful. Consequently, the figures may be taken as fairly indicative of the range of losses to be expected when fairly sound field-run stock, including practically everything produced except undeveloped strings, is employed. It is obvious from the data that the amount of loss in machine peeling is directly related to the shape and size of the roots of the variety and especially to the degree of irregularity—lobing or grooving—present.

TABLE 1.—*Losses in peeling with boiling lye or by abrasive machine, immediately after digging or after curing and storage, for 39 varieties and strains of sweetpotatoes*

| Variety | Size and form | Loss immediately after digging | | Loss after curing and storage | |
|---|---|---|---|---|---|
| | | Lye peeling | Machine peeling | Lye peeling | Machine peeling |
| | | *Percent* | *Percent* | *Percent* | *Percent* |
| Ballinger Pride | Large, fusiform | 19.4 | 23.0 | 18.6 | 24.1 |
| Belmont | Medium, fusiform | 17.5 | 22.4 | 16.2 | 23.7 |
| Big Stem Jersey | Long, fusiform | 17.8 | 20.2 | 15.6 | 23.3 |
| Catawba Yellow | Small, peg top to globular | 21.6 | 24.0 | 21.0 | 24.9 |
| Creola | Smooth, fusiform to blocky | 18.5 | 23.7 | 17.6 | 21.6 |
| Dahomey | Long, rootlike | 22.6 | 30.1 | 23.0 | 29.7 |

TABLE 1.—*Losses in peeling with boiling lye or by abrasive machine, immediately after digging or after curing and storage, for 39 varieties and strains of sweetpotatoes*—Continued.

| Variety | Size and form | Loss immediately after digging | | Loss after curing and storage | |
|---|---|---|---|---|---|
| | | Lye peeling | Machine peeling | Lye peeling | Machine peeling |
| | | *Percent* | *Percent* | *Percent* | *Percent* |
| Dooley | Large, peg top | 16.6 | 23.1 | 18.5 | 26.4 |
| Early Red Carolina | Medium, smooth, spindleform | 20.0 | 23.5 | 19.2 | 23.8 |
| Early Carolina | Small, fusiform-stringy | 19.2 | 23.0 | 17.6 | 24.1 |
| Florida | Medium, long fusiform | 18.2 | 23.4 | -------- | 23.2 |
| General Grant Vineless | Medium, fusiform | 18.8 | 23.4 | 18.8 | 27.8 |
| Georgia | Medium, irregular lobed | 18.2 | 24.4 | 18.6 | 26.1 |
| Gros Grandia | Long, stringy, veined | 20.7 | 27.0 | 22.4 | 29.2 |
| Gold Skin | Small, smooth, fusiform | 18.4 | 22.3 | 18.8 | 23.1 |
| Haiti "yam" | Large, irregular, grooved | 18.2 | 26.7 | 20.1 | 28.9 |
| Japanese "yam" | Long cylindrical, irregular | 16.5 | 26.7 | 17.7 | 26.4 |
| Key West "yam" | Large, cylindrical | 20.3 | 27.9 | 19.4 | 30.0 |
| Mameyita | Medium, globular ovoid | 19.0 | 27.6 | 18.1 | 22.4 |
| Miles "yam" | Medium regular, fusiform | 18.3 | 24.6 | 19.5 | 26.6 |
| Mullihan | Medium smooth, fusiform | 18.1 | 22.6 | 18.9 | 22.6 |
| Myers' Early | Medium to small, fusiform | 16.7 | -------- | 18.9 | 29.5 |
| Nancy Hall | Medium to large, fusiform | 19.2 | 21.8 | 19.9 | 22.8 |
| Old Time "yam" | Medium, spindle-cylindrical | 18.6 | 24.1 | 19.3 | 25.5 |
| Norton | Medium to large, fusiform | 16.6 | 20.0 | 21.2 | 26.0 |
| Pierson | Large, ovoid, deeply grooved | 19.3 | 26.4 | 19.9 | 28.9 |
| Porto Rico | Large, globular, irregular | 19.1 | 27.3 | 18.9 | 29.3 |
| Pumpkin "yam" | Medium, irregular | 18.5 | 26.4 | 17.8 | 28.3 |
| Purple "yam" (Nigger Choker) | Long, irregular, rootlike | 23.6 | 27.4 | 24.4 | 30.3 |
| Red Bermuda | Medium to large, ribbed, globular | 19.8 | 31.4 | 18.6 | 24.7 |
| Red Brazil | Large, globular, irregular, grooved | 17.9 | 23.4 | 18.1 | 23.2 |
| Red Jersey | Small, fusiform, smooth | 17.6 | 21.6 | 18.0 | 20.6 |
| Southern Queen | Medium, globular to ovoid, ridged | 19.9 | 24.7 | 19.0 | 25.2 |
| Triumph | Medium cylindrical | 17.8 | 24.7 | 18.6 | 28.2 |
| Vineless Pumpkin "yam" | Medium, smooth, fusiform to cylindrical. | 18.3 | 23.4 | 18.8 | 24.4 |
| Vineland Bush | Medium, fusiform to ovoid | 17.7 | 23.4 | 17.6 | 24.5 |
| White "yam" | Large oblong to fusiform, grooved | 19.6 | 26.4 | 20.7 | 28.8 |
| Yellow Jersey | Medium, fusiform to globular | 16.9 | 19.8 | 18.6 | 22.5 |
| Yellow Strasburg | Large, ovoid-globular, grooved | 18.3 | 29.7 | 15.1 | 25.7 |
| Yellow "yam" | Medium to large, veined | 19.6 | 23.6 | -------- | 27.7 |

## INSPECTION AND TRIMMING

The examination of the sweetpotatoes during washing permitted discovery and rejection of all badly decayed roots; but a further close inspection of the peeled stock is absolutely necessary, as it will reveal incipient stages of decay not evident prior to peeling. The tips of the roots should be examined for any signs of discoloration of the vascular bundles or other evidences of disease, and sweetpotatoes showing such indications should be either radically trimmed or discarded entirely. The use of lye peeling helps in the detection of some cases of disease which might otherwise escape notice, as contact with lye intensifies the darkening of the vascular bundles in the affected area.

## SLICING

The material was prepared for drying chiefly in two forms—as slices cut transversely or longitudinally about one-fourth inch in thickness, or by cutting the potato longitudinally, as a watermelon would be sliced, into triangular strips about three-fourths inch in thickness, and consequently varying in number with size of the sweetpotato. The use of a power-driven root chopper having a series of adjustable knives set in a rotating disk for slicing did not prove satisfactory, for while the machine had large capacity, the feeding of the sweetpotatoes to the knives through a hopper resulted in the production of slices cut at various angles through the root. This detracted seriously from the appearance of the dry material, and the use of the machine was abandoned. Much of the slicing was done with a hand-slicing machine designed for the slicing of apples. The essential features of the machine consisted of a sloping bank of knives set one-fourth inch apart in a frame and a sliding arm by which the sweetpotatoes were pushed, one at a time, through the bank of knives. While perfectly satisfactory within its working limits, this machine had the disadvantages that very large roots had to be cut up, as the knife bank would not admit them, and that considerable effort was required to drive the sweetpotatoes through the knives.

Some use was also made of a hand-power rotary slicer having an adjustable knife which permitted the cutting of slices of any desired thickness. As sweetpotatoes were individually fed to this machine, slices could be cut either transversely or longitudinally, and its size permitted handling roots of any size. Transverse slices were of uniform thickness, but varied greatly in size, and there were many small disks cut from the tips of the roots. After the sweetpotatoes had been steamed, the slices tended to stick together, and there was some difficulty in spreading them uniformly on the drying trays. The varying size of the slices also contributed to irregularity in the rate of drying. The vascular bundles became more prominent during drying as a result of the shrinkage of the storage parenchyma, which in some varieties left the ends of the bundles standing in relief upon the surface of the transverse slices. Finally, the wide variation in size of slices detracted somewhat from the appearance of the dried product, whether cut longitudinally or transversely.

For these reasons, much of the material in later work was prepared by cutting the sweetpotatoes longitudinally into triangular strips about three-fourths inch in thickness. No satisfactory machine for cutting such strips rapidly was found, and the work was consequently done by hand. A little practice enabled an operator to cut sweetpotatoes of widely varying size into strips of quite uniform cross section. Such strips had very little tendency to adhere together after cooking, dried quite uniformly and somewhat more rapidly than slices, and presented a more attractive appearance when dry.

## PREVENTION OF DISCOLORATION

Magoon and Culpepper have given considerable attention to the causes of the discoloration which appears in most varieties of sweetpotatoes on peeling and cooking and to methods of preventing its occurrence in canning (*6, table 4, 31, pp. 13–16*), and Johnstone (*26*) has studied the oxidase system responsible for the discoloration. Magoon and Culpepper found that some degree of discoloration upon exposure to air occurred in all the varieties studied, but that it was most pronounced in deeply pigmented varieties, such as many members of the Spanish group, least evident in the Jersey group, and variable in amount in other groups. They showed that the discoloration appeared in material exposed to the air after autoclaving for 1 hour at 116° C., hence does not require the presence of the active enzyme for its occurrence. They employed various chemical treatments, including dipping into acetic, tartaric, or sulphurous acid solution, or into dilute sodium chloride, in the attempt to control the process. The acids used were effective, but sufficient quantities were carried into the canned product to be detectable by taste. They were able to obtain very effective control without any chemical treatment by reducing the exposure of the material to air after cooking by prompt packing into cans and immediate sealing while the temperature of the material was at least 70°.

In the present work, discoloration was one of the chief difficulties to be overcome, as even those varieties that Magoon and Culpepper found to be least likely to become discolored became quite badly darkened during drying. All the conditions necessary to efficient drying, such as subdivision of the material into thin pieces of large surface area, free exposure to a large volume of air, and the maintenance of fairly high temperature, are such as favor oxidative processes. Varying the length of the cooking period or autoclaving the material at temperatures up to 120° C. had little or no effect in preventing discoloration, as reported by Magoon and Culpepper (*31, p. 15*), which indicates that the problem is one of auto-oxidation. The discoloration at the surfaces of the slices appeared rather promptly after the material was placed in the drier, extending into the material along the vascular bundles, and spreading and deepening in hue as the drying advanced. While this darkening largely disappeared in the processes of soaking and cooking the material, it made the dry product so unattractive in appearance that it was necessary to find a method which would effectively prevent darkening despite the presence of optimum conditions for its occurrence.

Various chemical agents, including sodium chloride, chlorine water, low concentrations of the mineral acids, the commoner organic acids, and a number of others were tested. Some of them were moderately effective in preserving unchanged color, but were objectionable in other respects, usually through injury to flavor of the product. Treatment with fumes of burning sulphur or placing in a solution of potassium metabisulphite for a few minutes prevented darkening, but also partially destroyed the carotinoids and bleached the material to an unattractive grayish-white or yellowish-white color. When concentration and time of treatment were reduced sufficiently to minimize the bleaching effect, control of darkening became imperfect. Acetic acid and tartaric acid were effective, but only when used in such concentrations and for such a length of dip that the product retained an acid taste when prepared for the table. This was also true of the mineral acids.

Submerging the sweetpotatoes for a short period in 2-percent citric acid was satisfactory in all respects for all varieties used in this work.[2] A 1-percent solution was effective for some varieties not especially subject to discoloration, but not for those most prone to it or for old stock that had been in storage for considerable periods. A

---

[2] The use of citric acid in the preparation of commercial dehydrated sweetpotatoes will necessitate a statement of its use on the label of the package. See p. 25.

2-percent solution was effective for all varieties under all conditions of previous handling. It did not appreciably increase the dextrinization of starch during the cooking of the sweetpotatoes, nor did it give an acid taste to the material when subsequently prepared for the table. Hence, treatment with 2-percent citric acid immediately after peeling and slicing and prior to cooking was adopted as a routine procedure in all the later years of the work. It was found that submerging the material in the acid solution, which was always used cold, for 3 to 5 minutes was quite as effective as allowing it to remain for longer periods, provided the sweetpotatoes were placed in the solution immediately after peeling and slicing and before superficial darkening had occurred. When darkening from exposure had already occurred, prolonging the time in the acid bath would largely or wholly restore the original color, as the oxidized substances diffused out into the solution. In such cases the material might absorb enough acid to affect the flavor when cooked.

The most effective method of preserving color and at the same time guarding against too much absorption of acid by the potatoes was found to be the use of two vessels of acid solution. As rapidly as potatoes were washed and trimmed after peeling they were dropped into a tank of acid solution and allowed to remain usually 3 to 5 minutes. They were then lifted out and delivered to the operators who cut them into slices or strips, which were dropped as rapidly as made into a second tank of acid solution. Here they were agitated sufficiently to separate the pieces and bring all surfaces into contact with the solution, allowed to remain 3 to 5 minutes, then dipped out and spread directly upon the drying trays without previous rinsing.

While the acid solution was gradually reduced in strength by use, it could be used for an entire day's work without renewal, and the solutions from the two tanks were sometimes combined, after straining to remove accumulated starch and broken bits of sweetpotato, and used for dipping peeled sweetpotatoes during a second day. When this was done it was found advisable to boil the solution, as the dissolved sugars and dextrins made it a very favorable medium for growth of various fermentation bacteria.

Throughout the process of slicing and spreading on trays, it was necessary to keep a close watch for indications of disease or decay which had escaped discovery while the roots were entire. Some varieties, for example, Southern Queen, Triumph, and Miles "yam," are subject to internal break-down in storage, developing cavities of visible size here and there throughout the root through solution of cell contents and obliteration of cell walls. Presence of these cotton-white areas in affected slices is readily detected, as are discolorations resulting from bruises or cuts, as the slices are spread. Such slices should be removed and trimmed or discarded.

## COOKING

It was necessary at the outset to determine the method and degree of cooking that would give a dried product of attractive appearance and satisfactory culinary quality. Various methods, including cooking in boiling water, in an autoclave at various steam pressures, and in flowing steam at 205° to 212° F. were used, and the time of cooking was varied from that necessary to cook the material completely to that which sufficed merely to heat it through. Lots of material subjected to these various treatments were dried, compared for appearance, stored for periods of several months to more than a year, prepared for the table, and compared for appearance, texture, flavor, and general quality, not only with one another but also with cooked products made from stored sweetpotatoes of the same varieties.

It was apparent from these tests that whatever the method of cooking employed it should be sufficiently prolonged to cook the material completely. Complete cooking by any method resulted in a pronounced intensification of color, due in part to removal of air from the tissues and in part to gelatinization of starch (*6*), which rendered the pieces somewhat semitransparent. The pieces readily broke on pressure, could be pulped between the fingers, and the texture and flavor was that of completely cooked sweetpotatoes.

Cooking in water had several disadvantages which early resulted in its abandonment. As the sweetpotatoes were cut into thin slices or strips having a large surface area in relation to their mass, the losses of solids by solution in the cooking water was several times as rapid as those reported by Gore (*12*), whose studies dealt with the losses occurring in the cooking of entire sweetpotatoes. Considerable quantities of water were absorbed, so that the time required for drying was increased. The material became greatly softened during cooking, and much crumbling and breaking of slices occurred in spreading them on the drying trays. Cooking in an autoclave under steam pressure minimized the absorption of water but resulted in some losses of solids, and the softening of tissues and consequent breaking of slices and marring of the appearance of the dried product was even greater than with cooking in water.

A method, which was found most satisfactory in all respects, was that of cooking the material with flowing steam after spreading on trays that were subsequently transferred to the drier. The sliced sweetpotatoes were lifted directly from the citric-acid solution, spread as uniformly as possible to a depth of ¾ to 1 inch upon trays made of heavy galvanized wire netting of ¼-inch mesh over which a layer of coarsely woven cheesecloth had been tacked to prevent direct contact of the potatoes with the metal,[3] placed in the steam box for the desired time, and transferred directly from it to the drier.

The steam box used in the work was a heavily built, double-walled wooden box, 5 feet in height and 3 feet in width and depth. Wooden cleats nailed horizontally to the inner walls 4 inches apart supported a series of 10 trays each 3 by 3 feet in size. The lower tray was placed 8 inches above the floor, and steam was supplied by two perforated pipes placed in this space, 1 foot apart, 3 inches above the floor, and extending from side to side of the box. The perforations were directed obliquely downward, so that the jets of steam did not play directly upon the material.

The box was provided with a closely fitting door and with a vent closed by a sliding board in the top, to aid quick replacement of the contained air by steam. The top of the box was slightly inclined from front to back, in order that condensation might be collected and carried down the rear wall instead of dripping upon the trays. By maintaining a fairly rapid flow of steam, the box could be brought to an internal temperature of 200° to 206° F. within 2 to 3 minutes and held within that range as long as desired. When heating up was rapidly done, there was practically no condensation of water on the sweetpotatoes, which neither gained nor lost weight appreciably during the steaming. The trays were then transferred directly to the drier, so that the crushing and breakage inevitable to handling or spreading cooked material was entirely avoided.

---

[3] The use of galvanized wire trays for steaming or drying sweetpotatoes is inadvisable unless some means of effectively preventing contact of the material with the metal is employed, as such contact will result in discoloration of the material. It may be prevented by giving the trays two or three coats of some quick-drying enamel of the type used upon automobile bodies, stoves, etc. The treatment should be repeated from time to time, in order to cover any breaks that may occur in use

### LENGTH OF COOKING PERIOD FOR CURED AND UNCURED SWEETPOTATOES

Considerable preliminary experimentation made it clear that the most satisfactory dried product was obtained when the material was so completely cooked in flowing steam that pieces were palatable when taken directly from the trays and eaten. To bring about this condition in uncured sweetpotatoes required a considerably longer period of steaming than in cured stock. As a routine procedure, steaming periods of 20 to 30 minutes for cured stock and of 35 to 40 minutes for freshly dug stock were employed in the comparative studies, the exact period varying slightly with the variety.

Steaming from 20 to 25 minutes at 200° to 206° F. was sufficient completely to cook previously cured stock of the soft-fleshed, moist types of sweetpotatoes, such as Nancy Hall, Porto Rico, Creola, and Southern Queen, when cut into slices one-fourth of an inch or strips three-fourths of an inch thick and spread upon trays to a depth not greater than 1 inch. With varieties of the firm-fleshed dry types, such as those of the Jersey group, 25 to 30 minutes' steaming of cured stock was necessary for complete cooking. Cured material cooked for these periods had the appearance and flavor of completely cooked sweetpotato when removed from the steam box. After drying, the slices were uniformly of a deepened, intensified color, were semitransparent, and broke with a glasslike fracture under pressure. They were smooth by reason of the presence of a glaze of dextrins and sugar upon the surface, did not readily take up moisture from the atmosphere but absorbed water rapidly when soaked, and required only short cooking to prepare them for the table.

Uncured sweetpotatoes of the same varieties, prepared in the same way, required 30 to 40 minutes' steaming to cook them completely, the firm-fleshed types requiring the longer period, while 30 to 35 minutes sufficed for the soft types. When given these periods of cooking, the steamed material still differed somewhat from that made from cured material in that the intensification of color and development of semitransparency was less pronounced, and that these differences persisted when the material had become dry.

When prepared for the table, the product made by identical methods from the uncured stock was distinctly firmer and more resistant to crushing or pulping and somewhat less sweet in flavor than that made from cured stock of the same variety. Consumers who prefer a fresh sweetpotato of the firm, nonmelting type would probably choose such a dried product in preference to that made from cured stock; those preferring a sweet, melting-fleshed sweetpotato would find the product from cured sweetpotatoes more acceptable.

The reason for these differences in character and behavior of the products from cured and uncured stock is found in the changes in composition that sweetpotatoes undergo during curing. Hasselbring and Hawkins (*22*, *24*) have shown that the carbohydrate content of the freshly dug sweetpotato consists almost wholly of starch, there being a very low sugar content, and that there is a rapid reduction in starch and increase in sugars after digging. The rate of this change of starch to sugar increases with increase in temperature up to 30° C. Culpepper and Magoon (*6*) investigated the changes in carbohydrates during the curing process in all the varieties used in their work, finding that the absolute amount of sucrose formed varied widely with variety, but was always very considerable. They confirmed Gore's finding (*13*) that large quantities of sugar, chiefly maltose, are formed during the cooking of the sweetpotato, and showed further that the greater sweetness and softness of the cured sweetpotato after cooking is due to the fact that curing and cooking together effects a much greater transformation of starch into dextrins, maltose, and sucrose than occurs in cooking alone. They pointed out the practical bearing of these facts upon the canning of sweetpotatoes, showing that the canner might make two products of very different character—one of firm consistency, high in starch, and low in sugar, the other of soft consistency, low in starch, and high in dextrins and sugars—from the same variety of sweetpotato by canning a portion of the stock before and the remainder after curing.

Precisely the same possibilities for control of the consistency and sweetness of the final product are present in drying as in canning, through the use of material with and without previous curing. The operator of a drier should decide upon the type of product that will be most acceptable to consumers and treat his raw materials accordingly. If he decides to dry sweetpotatoes both before and after curing, it is essential that he regard the two products as entirely distinct and keep them separate in the subsequent storage and handling.

In one group of experiments an attempt was made to determine whether the use of a prolonged period of steaming with uncured stock would result in a dried product having a consistency and character, when prepared for the table, more closely resembling that of cured stock. It was hoped that, since the enzyme responsible for transformation of starch into sugar is active during the cooking process, prolonged heating of the material at a temperature below that which would destroy the enzyme might result in a transformation of starch somewhat comparable in amount with that which occurs in curing. This result was not wholly realized.

Holding the sliced material in the steam box for periods of 1 to 2 hours at temperatures ranging from 125° to 175° F. resulted in considerable dextrinization of starch and some increase in sweetness, but the dried material when prepared for the table had the firm consistency of uncured sweetpotato. There was much condensation of water on the material, which became water-soaked and sticky, and the dried product was difficult to remove from the trays. Also, the control of discoloration proved to be much more difficult than in material handled in the usual way. As the results did not seem to justify further work along this line, the experiments were discontinued.

### PREPARATION OF GRANULATED OR RICED SWEETPOTATO

The method for preparation of sweetpotatoes for granulating or ricing was identical with that followed with slices or strips insofar as washing and peeling with lye or by machine was concerned, but differed radically in later steps. The peeled sweetpotatoes were sliced or coarsely ground by passing through a food chopper, submerged in 2 percent citric acid for 5 minutes, spread on trays, completely cooked in flowing steam, removed from the trays, and immediately passed through a pulper which reduced the hot material to a pulp and forced it through a plate having numerous $\frac{3}{16}$-inch openings. The pulp issued from these openings in continuous strands that adhered together without coalescing, forming an untwisted rope that could be drawn out to considerable lengths. These ropes of pulp were placed side by side upon trays and immediately placed in the drier. By reason of the fairly fine subdivision of the material and the open, porous character of the strands, drying was completed within 4 or 5 hours.

Considerable difficulty was encountered in preventing discoloration in the granulated sweetpotato. Dipping into citric acid was effective only for the surfaces actually wetted by the acid, and when material was dipped in the form of slices and subsequently ground, darkening on exposure to the air occurred in the inner portions of the pieces not in contact with the acid. The process of pulping incorporated so much air into the material that this darkening occurred quite rapidly and generally throughout the strands of drying material. Cutting the sweetpotatoes into small bits prior to dipping reduced the amount of discoloration, but it was not entirely prevented even when the sweetpotatoes were ground to particles slightly larger than a grain of wheat before dipping.

Prolonging the submersion of the ground material in citric acid to 12 or 15 minutes gave good control of color, but the material frequently absorbed so much acid that the taste when prepared for the table was affected. The ground sweetpotatoes became quite gummy and stuck together badly on the trays during cooking and consequently were difficult to handle through the pulping machine. The dried product was bulky, having 10- to 25-percent greater volume than the stock from which it was made, and was strongly hygroscopic, requiring sealed containers for prolonged storage. Grinding the dried material to a rather fine meal in a drug mill reduced its bulk somewhat, but the ground product would readily absorb water and cake as did the flour made by Mangels and Prescott (*33*).

Reducing the period of cooking in steam to 10 to 12 minutes lessened the stickiness of the material and the difficulty in handling through the pulper and gave a product somewhat lighter in color and less hygroscopic than that obtained on longer cooking. It had the disadvantage that in spite of efforts to secure uniform spreading on the cooking trays, some portions of an occasional tray would be undercooked. When prepared for the table, these undercooked portions absorbed water more slowly than the remainder and would be underdone and woody when the product was served.

At the outset of the work it had been felt that the making of a granulated product offered opportunities for the use of small, irregular or rootlike sweetpotatoes not suitable for use in other forms. Such material made a product comparing very favorably with that from sweetpotatoes of marketable size, but yields of the dry product were lower because of the larger percentage of waste in peeling. The making of granulated potato seemed to have few if any practical possibilities when compared with the making of slices or strips. Its preparation required nearly twice as much labor, it was much more difficult to prevent discoloration and to secure uniform cooking, the product was bulky and required airtight containers for storage, and it could be used only as a pie filler or as a pulped or mashed sweetpotato. For these reasons, making of the granular product was not continued as a routine procedure in the comparative studies of varieties.

## DRYING

### TYPES OF DRIERS EMPLOYED

### THE NATURAL-DRAFT TUNNEL EVAPORATOR

In all the earlier work, the material was dried in a prune-tunnel evaporator of the type described by Caldwell (*3*). As the term "tunnel" evaporator has been loosely applied to a variety of drying devices, some of which are entirely devoid of the features upon which the efficiency of the tunnel evaporator depends, the essential characters of the drier used are stated herewith. The evaporator consisted of three units or chambers each 20 feet in length, 6½ feet in height, and 3 feet in width, placed side by side. Floors and ceilings had an inclination from the horizontal of 2 inches per foot of length, so that one end of the tunnels was 3⅓ feet higher than the other. Heat was supplied from a coal-burning furnace placed centrally beneath the lower end of the tunnels and supplied with two lines of pipe carried beneath the floors of the lateral tunnels, to aid the heating. Inlets in the wall of the furnace chamber admitted air from outside the building, which was warmed by passing over the furnace and pipe before entering the tunnels through rectangular openings in the floor at their lower end. The opposite, higher end of the group of tunnels was provided with a ventilating shaft 2 feet in depth, extending across the entire width of the tunnels and rising well above the roof of the building, to secure draft regardless of outside conditions.

The trays of material to be dried were supported one above the other by a series of wooden cleats nailed 4 inches apart to the side walls of the tunnel parallel with floor and ceiling. In operation, trays of freshly prepared material were always introduced at the higher end of the drier, gradually pushed along by the insertion of others behind them as drying proceeded, and removed at the lower end when dry. Since the temperature at the upper end was usually 25° to 30° F. below that at the lower end, this arrangement provided for a moderate temperature at the outset of the drying and a progressive increase in temperature as the drying proceeded. The operation also was continuous in that material might be placed in the drier as prepared, space being made for it by removal of that which had become dry.

Rather uniform distribution and fairly rapid flow of the heated air throughout all levels of the tunnels was secured by "banking" or offsetting the trays. In loading the lowest runway, the foremost tray was pushed down until its edge projected 1 to 2 inches beyond the edge of the hot-air opening in the floor. The trays on the second runway were so placed that the edge of the foremost projected about 2 inches beyond that on the first runway, and a similar arrangement was followed in loading the other runways. The trays on each runway were pushed tightly together, edge to edge, with the result that each tier of trays formed a continuous baffle-plate, its lower end projecting 2 inches farther over the hot-air intake than that just beneath it, while there was a corresponding free space for exit of air between the tiers of trays at the upper end.

As a result, the ascending column of warm air was broken up into a series of streams that were forced to flow between tiers of trays throughout the length of the tunnel. In consequence, there was a rather uniform distribution of the heat supplied through all levels of the tunnel, unimpeded escape of moisture-laden air into the ventilator, and a rate of drying that was fairly uniform at the bottom, middle, and top of the tunnel at any given point in its length.

The air taken into the furnace room came directly from outside the building, hence entered with the temperature and moisture content of the outside atmosphere. As most of the work was done in late autumn and winter, outside temperature and humidity varied widely. By proper attention to the firing of the furnace and to adjustment of the air inlets to the furnace room and those from the furnace room to the tunnels, it was possible to maintain any desired temperature at the inlet end of the tunnel within a range of 10° F. during the drying of a charge, regardless of the outdoor conditions. No attempt was made to control the humidity of the air entering the tunnels. As its temperature was usually increased by 100° or more during its passage over the furnace and heating coils, the air entering the tunnels was always low in relative humidity even when the outside atmosphere was approximately saturated, since the moisture-carrying capacity of air is practically doubled by every increase of 27° in temperature. Danger of case-hardening the material was minimized by the method of loading the drier, which passed the incoming hot, dry air over material that already was partially dry before permitting contact with fresh, water-filled material.

### THE FORCED-CIRCULATION DRIER

In the more recent work, a steam-heated chamber drier was employed in which circulation of air was maintained by a fan. The apparatus, built in the laboratory, consisted of a drying chamber 6 feet in height, 4½ feet in width, and 3 feet in depth, built of fiberboard with an inner lining of asbestos board. It was provided with supports for carrying 15 trays placed one above another 4 inches apart, with a space 12 inches in depth below the lowest tray that served as an air-mixing chamber. Heat was supplied by a radiator coil placed outside the drying chamber and enclosed by asbestos board. A motor-driven blowing fan placed outside the radiator enclosure and connected with it by a short section of 6-inch pipe forced a rapid current of air through the radiator coils and into the mixing chamber at the base of the drying chamber, whence it rose through the trays to escape at the top, which was left open except for a covering of muslin to exclude dust.

In common with other driers in which the current of air must pass through a series of trays of material instead of flowing over and between them, the temperature and the rate of drying were greatest at the bottom and decreased toward the top. As the chamber was 4½ feet in length, this difficulty was partially overcome by employing trays 3 feet in width and placing them alternately at the right and left sides of the box. This arrangement brought about approximately the effect upon the air flow that is present in the tunnel drier, as the air currents were forced to flow over and between the trays instead of passing upward through them. As a consequence of the rapid air movement produced by the fan, the difference in temperature at bottom and top of the drier was usually not more than 10° to 12° F., and it was necessary to operate the drier at a lower temperature at the warm-air inlet than in the case of the tunnel drier, to avoid rapid superficial drying and consequent case-hardening of fresh material.

The air-inlet temperatures used throughout the work with this drier ranged between 150° and 160° F., but use of these temperatures was made possible only because the drier was built within the laboratory and took its air supply from that of the room, which was usually warm and quite humid as a result of escape of steam from other apparatus within it. But for this fact, the use of a humidifying device or of a considerably lower temperature would have been necessary.

Neither of the driers employed in the work was satisfactory in the efficient use of the heat employed, but they were both of the general type quite widely used in fruit-drying operations and had the merit of simplicity and ease of control. The fact that satisfactory products were made by their use would indicate also that the employment of more efficient equipment would give at least equally satisfactory results.[4]

## TEMPERATURES EMPLOYED IN DRYING

A fairly comprehensive series of experiments was carried out prior to the beginning of the comparative studies upon varieties, in order to determine the effect of drying at various temperatures upon the appearance and culinary quality of the product and to ascertain whether there is an optimum temperature range within which best results are secured.

The temperatures employed ranged from those just sufficient to prevent growth of organisms in the freshly prepared material up to those that produced caramelization and charring in material which was nearly dry. The results of these experiments indicated that there is a fairly wide temperature range within which previously cooked sweetpotatoes may be dried without much difference in appearance or culinary quality. When a large lot of sweetpotatoes was subdivided into portions that were dried at various different and constant temperatures between 120° and 160° F. the dried products were practically identical in appearance and became indistinguishable in color, texture, and flavor when prepared for the table. There were very considerable differences in the efficient use of the heat supplied and in the time required for drying at the various constant temperatures, both decreasing together as the temperature used was increased up to 160° F. For temperatures above 160°, increase in the temperature of the air supplied did not bring about further decrease in drying time, but usually increased the time required to bring the material to a given residual moisture content. The reason for this result is that the material becomes dry by a process of diffusion of water outward from the interior of the pieces to the surface, where it is vaporized and lost to the atmosphere. The rate of vaporization of water at the surface, other factors being constant, depends upon the water-absorbing capacity of the air, which progressively increases with increase in temperature. The rate at which water can be supplied to the surface from the interior of the pieces of material depends upon a large number of factors, among which may be mentioned the physical structure and chemical composition of the material and its condition, whether living or killed, and the ratio of surface area to volume of the individual pieces.

---

[4] Those interested in a presentation of the engineering principles involved in drying and of the factors involved in efficiency of evaporating equipment will find these discussed in papers by Christie and Ridley (*5*), Cruess and his associates (*7, 8, 9*), Nichols, Powers, Gross, and Noel (*37*), Wiegand (*51*), Tiemann (*50*), and Thelen (*45*).

So long as the rate of vaporization of water at the surface of the material does not exceed that at which water can diffuse from the interior, drying will proceed by vaporization from a continuous film of moisture covering the surface. When the rate of vaporization at the surface exceeds that at which renewal of the surface film can occur, a thin layer at the surface of the material will become dried out and consequently will reduce the rate of drying in a fashion exactly analogous with the case-hardening of green lumber when subjected to excessive temperatures in drying. It follows that drying of any material will be most efficiently accomplished by the use of temperatures that vaporize water from the surface at a rate nearly equal to but always slightly less than that at which the surface film can be renewed by transfer of water from the interior.

In practically all the work with material used in the comparative varietal studies, drying was begun in air having a temperature of 135° to 150° F. and a relative humidity of 25 to 35 percent. As the drying proceeded the air temperature was progressively increased and its relative humidity decreased so that the process was finished with an air temperature of 160° to 165° and a relative humidity of 12 to 15 percent. In the tunnel drier, these differences in beginning and finishing temperature and humidity are inherent in the method of operating the device. In the forced-draft chamber drier, the differences in temperature in different parts of the apparatus were rarely more than 10° to 12°, and the air-inlet temperatures were kept between 150° and 160°. The humidity of the entering air ranged between 15 and 22 percent and that of the escaping air between 40 and 50 percent. Products dried under these two sets of conditions showed no discoverable differences, either in the dry condition or when prepared for the table.

From the results of these experiments it appears that there is a fairly wide range of drying temperatures that may be used with the sweetpotato without injury to the product. Under the conditions of this work, 160° to 165° F. was the upper limit; use of higher temperatures with fresh or partially dried material produced the case-hardening effect already discussed, and temperatures above 180° produced an unpleasant caramelized or scorched flavor in the material when subsequently cooked. The limiting factor upon the use of higher temperatures in these experiments was, of course, the accompanying reduction of the relative humidity of the air; higher temperatures might have been employed with satisfactory results if a means of humidifying the air had been used, but this was not done.

The lower limit of temperature that could be employed without injury to quality of the product was 120° to 130° F.; at such temperatures the drying was unduly prolonged, but color and table quality were satisfactory. When drying was attempted below 120°, the material showed a tendency to darken in the interior of the pieces while the surface remained normal in color, and there were cases in which some growth of organisms occurred. Since the temperature of material from which free evaporation is occurring is always considerably below that of the surrounding air, the lower limit of temperature employed in drying must be high enough to make it impossible for thermophilic organisms to multiply. In these experiments, an air temperature of 120° to 125° appeared to be the limit below which difficulty with internal discoloration, growth of organisms, and fermentation of sugars was frequently encountered.

## END POINT OF THE DRYING PROCESS

At the outset of the work, lots of material from a number of varieties representing all the important groups were dried to various residual moisture contents, as determined by calculation from the dry weights and the known moisture content of the material. These were stored under various conditions as to temperature and humidity, with and without protection from access of atmospheric moisture. From time to time they were examined for changes in appearance and weighed to determine changes in moisture content. Some of the material so treated had been completely cooked, while some lots had received shorter steaming and presented the opaque appearance and mottled whitish-yellow color characteristic of partially cooked dried sweetpotatoes. The partially and completely cooked lots showed differences in behavior in storage directly attributable to the difference in thoroughness of the cooking prior to drying.

In completely cooked material, various lots dried to residual moisture contents ranging between 5 and 15 percent withstood storage in nonairtight containers in an ordinary storage room for periods of 8 months to 2½ years without permanent change in moisture content. There was a slight increase in weight during prolonged periods of high humidity, due to absorption of water by the varnishlike film of sugars and dextrins covering the pieces, which became somewhat sticky to the touch. This was followed in periods of normally dry atmospheric conditions by gradual drying out and return to the original weight, without change in color or flavor when cooked. The amount of change was small in all these lots, but was least in those originally dried to lowest residual moisture content.

In lots with 16- to 18-percent moisture content, the absorption of water during humid periods was considerably greater, the pieces of material tended to adhere together in masses, and subsequent drying out in periods of low humidity was slow and somewhat incomplete. In lots having 20 percent or more of moisture at the outset of the experiment there was progressive absorption of moisture, which resulted, after periods of 6 to 15 months, in caking together of the entire mass, development of moldiness, and spoilage. At the end of 2½ years in a laboratory storage room kept at ordinary living-room temperatures, all the lots having original moisture contents of 5 to 15 percent were still in good condition as to color and flavor, with weights varying from 97 to 106 percent of the original.

The lots having original moisture contents of 16 to 19 percent had increased 10 to 12.5 percent in weight, but were fairly good in color and acceptable in quality when cooked. Those having moisture contents of 20 percent or more at the outset had developed mold and spoiled after absorption of moisture ranging from 20 to 35 percent of the original weight. Most of this last group had been spoiled and discarded within the first year of the test. In the very warm, humid conditions prevailing in a laboratory in which the air was frequently saturated for considerable periods by escaping steam, lots of material having more than 15 percent moisture also progressively gained moisture to the point at which molding and spoilage occurred after periods of 5 to 9 months.

Material that had been only partially cooked and that consequently retained considerable quantities of unaltered starch, absorbed water from a humid atmosphere much more readily than the completely cooked material, and also gave it up more slowly and incompletely during dry periods. Mold developed much more quickly, possibly by reason of the lower concentration of dextrins and sugars at the surfaces of the pieces. All the lots of partially cooked material having residual moistures above 15 percent retained most of the absorbed water during subsequent dry periods, and ultimately developed mold after a few months.

No fading of color or alteration of odor or flavor occurred in either completely or partially cooked material that had less than 15 percent of residual moisture, was stored in nonairtight containers, and had been held in an ordinary laboratory storage room for 2½ years.

For these reasons, the material employed in the comparative studies of varieties was dried to a residual moisture content of 12 to 15 percent as nearly as this could be approximated from the fresh weight, the loss in peeling and preparing, and the average solids content of the variety, as indicated by the data of Culpepper and Magoon (*6*, *31*). This moisture content was regarded as safe for storage under any reasonable conditions. Reduction of moisture content to a very low point did not appear to add appreciably to safety in storage, prolonged the drying time very considerably, and had the positive disadvantage that the material would subsequently absorb water rather slowly when being prepared for cooking.

## PACKING AND STORAGE OF THE DRIED PRODUCT

A rather wide variety of containers, ranging from airtight or practically airtight metal cans to wooden and cardboard boxes, with and without waxed paper linings, and cloth and paper bags of various types, has been employed for storing the dried material for prolonged periods in ordinary laboratory storage rooms, heated or unheated, and also in a room chosen for the reason that the high humidity prevailing much of the time afforded conditions for very severe tests. As a general result of these tests it was shown that for properly prepared and adequately dried material, airtight containers are not necessary if the storage conditions are at all normal.

However, it was shown to be indispensable that the container be sufficiently tight to exclude insects and that it be of such material that they cannot cut through it to get at the contents. The rooms used for storage in these experiments also contained various other dried products, including apples, peaches, berries, corn, beans, peas, and other vegetables. The rooms occasionally became infested with a variety of insects feeding upon such material, affording a rather severe test of the ability of the containers used to exclude insects. Insofar as these experiments indicate, the insects usually attacking dried fruits are not attracted by dried sweetpotatoes, and adults and larvae of the common dried-fruit pests, such as the Indian meal moth, were practically never found in sweetpotatoes, even in packages they might have entered without difficulty. No deposition of eggs of the Indian meal moth was ever observed upon dried sweetpotatoes exposed in the storeroom.

The situation was very different with respect to various grain and flour beetles and weevils, which were apparently definitely attracted by dried sweetpotatoes and infested any container not tight enough to keep them out. Since many of these forms are able to multiply indefinitely in dry material, infestation was usually equivalent to destruction of the lot of material invaded. As some of these insects, among others the tobacco beetle, the drug-store beetle, and many species of weevils, can cut through paper, the use of ordinary paper bags as containers almost invariably resulted in infestation. Cellophane bags were free of infestation if so closed at top as to prevent entrance through the closure.

The use of wooden boxes provided with a lining of one or two layers of waxed paper, essentially duplicating the package used for evaporated apples, peaches, and prunes, reduced infestation to an occasional package to which the insects apparently gained access between imperfectly folded liners, as no evidence that the paper had been cut through could be found. Compressed paperboard boxes and paraffined paper cartons, when provided with closely fitting sliptop or snap-top closures, were perfectly satisfactory. Very closely woven bags of lightweight muslin prevented weevil infestation, as weevils do not cut through cloth, but an occasional bag was invaded by tobacco or drug-store beetles or other small forms which apparently gained access through faulty seams or imperfect closures rather than through the meshes of the cloth. Screw topped and sliptop tin cans were ideal containers and were generally used for holding lots for long periods for comparative purposes.

When all factors are considered, paraffined paper cartons or tin cans, provided with sliptops fitting tightly enough to exclude insects and to remain in place in handling, are preferable to other types of containers because they not only exclude insects but also protect the material from dust, accidental wetting, and the like. An inner lining of waxed paper might be used in the case of tin cans, although no injury to the product resulted from its omission in many lots of material stored for prolonged periods and under a fairly wide range of conditions.

Whatever the character of the package in which dehydrated sweetpotatoes are offered to consumers, the label must inform the purchaser that citric acid has been employed in the preparation of the material. It is a requirement of the United States Food and Drug Administration that the addition to foodstuffs of harmless substances not normally expected by the consumer requires a plain and conspicuous announcement of their presence on the label.

## YIELD OF DRY PRODUCT OBTAINED

All data as to dry yields obtained in the course of the work with 39 varieties and strains of sweetpotatoes have been brought together in table 2. For comparison with the data on yields, the results of determinations of total solids content, both before and after curing, taken from the work of Culpepper and Magoon (*6, pp. 636–637*) have been added for all the varieties studied by them. Their analyses were made from material grown from the same seed stocks and under the same soil and cultural conditions, and in part upon portions of the same lots of sweetpotatoes as those here used, hence are truly representative of the material here used. Varieties for which no solids content data are given were not analyzed by Culpepper and Magoon, and no comparable analyses have been found for them in the literature.

For the present purpose, yields obtained from various lots of a variety peeled by machine and by means of lye have been averaged together, giving results intermediate between those which would have been obtained had the two methods of treatment been averaged separately. Results have been stated as percentages of the gross weight of sweetpotatoes prior to peeling and trimming and as percentages of net weight of peeled, trimmed stock. Comparison between these two sets of values brings out some significant facts. From inspection of the table it is at once apparent that there is no consistent relation between yields as calculated on the two bases, as low yields on the whole-stock basis may occur with high yields on the peeled, trimmed basis, or both may be low or high together. The reason is that yields calculated on the basis of peeled, trimmed stock are determined by the solids content of the edible portion of the variety and by that factor alone, whereas yields calculated on the whole-stock basis are determined not only by the solids content but also by such factors as shape, size, and smoothness or roughness of form, which determine the ratio of cortex to flesh and also govern the amount of flesh that will be lost in peeling.

TABLE 2.—*Yields of dry product as percentages of whole stock and of peeled, trimmed sweetpotatoes processed immediately after digging and after curing and storage for 39 varieties and strains*

| Variety | Yield before curing | | Yield after curing | | Total solids [1] | |
|---|---|---|---|---|---|---|
| | Whole stock | Peeled, trimmed | Whole stock | Peeled, trimmed | Before curing | After curing |
| | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| Ballinger Pride | 28.0 | 32.9 | 27.4 | 33.8 | 31.22 | 33.36 |
| Belmont | 27.9 | 31.4 | 27.5 | 32.2 | ------- | ------- |
| Big Stem Jersey | 24.7 | 28.5 | 21.5 | 28.3 | 32.26 | 29.68 |
| Catawba Yellow | 25.6 | 31.1 | 26.6 | 30.9 | 34.92 | 33.28 |
| Creola | 22.5 | 30.8 | 24.0 | 31.1 | 29.11 | 31.16 |
| Dahomey | 21.4 | 31.1 | 22.6 | 32.2 | 33.11 | 33.66 |
| Dooley | 25.4 | 33.4 | 26.0 | 34.4 | 32.73 | 35.85 |
| Early Red Carolina | 24.6 | 30.0 | 23.3 | 28.9 | ------- | ------- |
| Early Carolina | 23.5 | 31.3 | 22.9 | 30.0 | ------- | ------- |
| Florida | 26.9 | 34.8 | 26.1 | 34.6 | 35.81 | 36.57 |
| General Grant Vineless | 28.2 | 33.6 | 27.7 | 33.1 | ------- | ------- |
| Georgia | 29.1 | 35.5 | 28.0 | 36.2 | 38.29 | 37.27 |
| Gros Grandia | 22.0 | 27.6 | 23.4 | 29.1 | ------- | ------- |
| Gold Skin | 24.4 | 29.9 | 24.2 | 30.3 | 28.58 | 29.06 |
| Haiti "yam" | 25.7 | 30.5 | 24.9 | 32.3 | 34.61 | 33.65 |
| Japanese "yam" | 22.4 | 30.5 | 25.0 | 34.8 | ------- | ------- |
| Key West "yam" | 27.8 | 31.3 | 27.6 | 30.9 | 30.58 | 32.43 |
| Mameyita | 24.4 | 33.8 | 22.4 | 28.5 | 31.39 | 34.61 |
| Miles "yam" | 25.0 | 32.1 | 25.7 | 33.0 | 32.47 | 32.72 |
| Mullihan | 26.9 | 33.3 | 27.7 | 32.9 | ------- | ------- |
| Myers' Early | 27.0 | 32.1 | 22.7 | 32.6 | ------- | ------- |
| Nancy Hall | 26.7 | 36.0 | 23.2 | 33.5 | 36.56 | 33.95 |
| Norton | 29.0 | 36.2 | 26.0 | 33.5 | ------- | ------- |
| Old Time "yam" | 26.8 | 31.5 | 25.5 | 30.9 | ------- | ------- |
| Pierson | 27.7 | 33.3 | 26.7 | 34.1 | 35.00 | 34.77 |
| Porto Rico | 21.5 | 29.5 | 23.2 | 32.2 | 30.16 | 31.88 |
| Pumpkin "yam" | 24.4 | 32.6 | 24.1 | 32.3 | 34.04 | 35.65 |
| Purple "yam" (Nigger Choker) | 29.1 | 34.8 | 26.6 | 35.0 | 37.73 | 36.58 |
| Red Jersey | 23.4 | 29.8 | 26.6 | 33.4 | ------- | ------- |
| Red Bermuda | 20.0 | 28.8 | 23.8 | 31.7 | 33.90 | 32.82 |
| Red Brazil | 26.5 | 35.2 | 27.9 | 36.7 | 33.76 | 31.60 |
| Southern Queen | 27.3 | 33.7 | 26.0 | 34.2 | 33.30 | 32.69 |
| Triumph | 24.7 | 33.3 | 22.1 | 33.9 | 38.28 | 38.02 |
| Vineless Pumpkin "yam" | 25.5 | 31.1 | 24.8 | 32.2 | 33.94 | 34.64 |
| Vineland Bush | 21.4 | 29.1 | 23.6 | 28.3 | ------- | ------- |
| White "yam" | 24.3 | 30.1 | 23.5 | 30.3 | ------- | ------- |
| Yellow Jersey | 23.3 | 29.1 | 22.7 | 30.8 | 29.17 | 30.48 |
| Yellow Strasburg | 24.8 | 35.3 | 25.7 | 36.2 | 33.39 | 37.98 |
| Yellow "yam" | 23.9 | 33.2 | 24.6 | 32.4 | ------- | ------- |

[1] Data upon total solids quoted from analyses of Culpepper and Magoon (*6*).

The yields obtained from peeled, trimmed stock range between 27.6 and 36.7 percent, those of most varieties ranging between 29 and 33 percent. There is usually quite close agreement in yields between cured and uncured stock of a given variety, and the yields obtained from a variety from lot to lot of material and from year to year also varied within quite narrow limits. Since the yields from prepared stock are so directly dependent upon the solids content of the material, this would be anticipated from the results of Culpepper and Magoon (*6*). These authors found that while total solids ranged between 27 and 39 percent in the 32 varieties studied by them, the total solids content of any given variety was relatively constant. A number of varieties studied by them, including Key West "yam," Creola, Porto Rico, and all the members of the Jersey group, had relatively low solids content, ranging between 27 and 32 percent; a small number, including Triumph, Georgia, and Purple "yam" (Nigger Choker), had very high total solids, ranging between 35 and 40 percent, while the remaining varieties ranged between 31 and 36 percent. Inspection of the data of Culpepper and Magoon (*6, pp. 636–637*) indicates that this last group might be subdivided into two, of which one, containing Florida, Haiti "yam," Nancy Hall, Pierson, Catawba Yellow, Vineless Pumpkin "yam," and Pumpkin "yam," ranges between 34 and 36 percent total solids, while the other, made up of Dahomey, Dooley, Mameyita, Miles "yam," Red Brazil, Red Bermuda, Southern Queen, and Yellow Strasburg, ranges between 31 and 33 percent.

The data of table 2 show very good agreement between yields from peeled, trimmed stock and total solids insofar as data for the latter are available. All the members of the Jersey group here used—Big Stem Jersey, Gold Skin, Yellow Jersey, Early Carolina, Vineland Bush, and Red Jersey—gave relatively low yields from peeled stock, as did Gros Grandia, Creola, Key West "yam," Old Time "yam," Red Bermuda, White "yam," Catawba Yellow, and a number of unnamed varieties and strains. Of the varieties that Culpepper and Magoon found to be high in solids, Georgia, Purple "yam," Yellow Strasburg, Florida, Dooley, and Red Brazil are highest in yield on the waste-free basis, followed by Pierson, Southern Queen, Ballinger Pride, Myers' Early, Nancy Hall, and Norton. The remaining varieties are intermediate in dry yield, and it may be noted that they include no varieties that are either extremely high or extremely low in total solids insofar as data on total solids contents are available.

Yields of dry product computed on the basis of whole stock used do not show any consistent relation to those obtained on the waste-free basis for the obvious reason that another varying factor, the amount of waste occurring in preparation, is involved in their determination. The amount of this waste is determined primarily by shape and size of roots and their degree of smoothness, also in some degree by the firmness with which the cortical tissues adhere to the flesh, a factor which varies with variety and previous treatment of the stock. In the discussion of peeling (p. 6) it has been pointed out that waste is minimum in amount in varieties of smooth, uniform fusiform or globoid-ovate shape and progressively increases with increasing irregularity in shape, and especially with lobing or grooving of the surface. While the shape of roots is relatively constant and characteristic in most varieties, it is affected within limits by fertilizer treatments and types of soil.

Size varies rather widely from year to year under the influence of seasonal conditions, and such changes affect the ratio of cortex to flesh and consequently the amount of waste in peeling. The detailed records of amount of waste in peeling and size of stock show for all varieties clear evidence of generally operative effects of seasonal conditions on amount of waste in peeling, through their effect on size. On the whole, table 2 shows very definite correlation between characteristic varietal shape and size and the amount of loss incidental to preparation for drying. Since total solids content and form of roots vary independently in the varieties, all possible combinations are found, and there is consequently no correlation between waste in peeling and dry yield computed as a percentage of the weight of whole stock used.

Yields computed on the whole-stock basis range between 20 and 29.1 percent. A number of varieties are especially low, ranging between 20 and 23.5 percent. These include Creola, Dahomey, Early Carolina, Gros Grandia, Porto Rico, Red Bermuda, Vineland Bush, and Yellow Jersey. About an equal number gave higher-than-average yields, ranging between 26.5 and 29.1 percent; these include Ballinger Pride, Belmont, Florida, Georgia, General Grant Vineless, Key West "yam," Mullihan, Norton, Pierson, Purple "yam," Red Brazil, and Southern Queen. The remaining varieties gave yields between 23.5 and 26 percent. Most of the varieties found by Culpepper and Magoon to be either markedly high or markedly low in total solids are in a corresponding group with reference to yield of dry product. There are some exceptions, chiefly varieties of high solids content, such as Haiti, Triumph, Nancy Hall, and Vineless Pumpkin "yam," which are not found in the high-yielding group, obviously by reason of irregularities of shape which entail rather high losses in preparation.

To summarize the preceding discussion, it is clear that except in varieties of highly irregular and variable shape the yields of dry product are determined primarily by total-solids content. In the irregularly shaped varieties, the yields of dry stock would be somewhat increased over the averages shown in the tables by the use of lye peeling; for varieties which are of such shape that they are efficiently peeled by abrasive machine, the gains in yield through the use of lye peeling are too small to be worth much consideration.

## COMPARATIVE STUDIES OF THE DRIED PRODUCTS

Some of the factors that would be of considerable practical importance in selection of varieties for drying purposes, such as amount of waste in preparation, difficulty in controlling discoloration, and yields, have been discussed in some detail prior to taking up the present topic for the reason that, important as these factors unquestionably are, they are secondary to those having to do with the appearance and attractiveness, especially the table quality and appeal to the palate, of the product. For this reason, the products from the various varieties were assembled and judged as to these qualities in both dry and cooked form, entirely without reference to the differences in difficulty of preparation or in yield of product. The various characters that determine degree of attractiveness and table quality—color and general appearance of the dry product, texture and appearance, flavor, and palatability in the cooked material—were individually determined and scored for each of the varieties by each of the judges, all of whom were individuals having some familiarity with sweetpotatoes. The judges were fairly successful in arriving at a common basis for judging each of the factors considered in the scoring, their differences of opinion arising chiefly out of differences in individual preferences for flavor and consistency of the cooked material.

## METHODS EMPLOYED IN PREPARING MATERIAL FOR COMPARISONS OF TABLE QUALITY

As a preliminary to comparative study of quality in the product, satisfactory methods of preparing the material for cooking and for converting it into forms ready for the table had to be worked out. Since the product was a new one, the literature gave little assistance. It was considered desirable to develop methods for use of the material in as many ways as possible—as mashed or creamed sweetpotato, pie filler, in baked and candied forms, and as French fried and sautéed sweetpotato. A rather comprehensive series of experiments covering all phases of the preparation and cooking of dried sweetpotatoes in all these various forms was carried on over several seasons with a number of representative varieties, the results being checked against those obtained by the use of fresh material of the same varieties, until it was felt that satisfactory methods of testing the material had been devised.

It seems unnecessary to say more of these experiments than will serve to indicate their scope. In the studies of soaking or refreshing, known weights of dry material were hydrated for measured time intervals in known amounts of water at various temperatures from that of the room to boiling point, the rate of water intake determined, and the effects of these treatments upon texture and flavor of the finished product compared. In the cooking tests the effects of additions of various quantities of sugar, butter, and salt, of baking at various oven temperatures, and the like, were determined. Repetition of the experiments with material grown under varying seasonal conditions and subjected to various periods of storage prior to drying aided in determining the degree to which conditions not under experimental control, such as varietal characteristics, seasonal conditions, or treatment prior to drying, might affect the results.

It was found as a general result that texture, flavor, and table quality could be more accurately compared when the material was prepared in more simple forms, as baked and as candied sweetpotato. The presence of the pastry in the case of pies, of milk, spices, and other ameliorations in the case of creamed sweetpotato, and the effect of frying in the case of sautéed or French fried sweetpotato, tended to mask differences in flavor. Consequently, while all the varieties considered as having any possibilities for drying purposes have been more or less thoroughly examined in all the forms mentioned, the statements as to comparative quality are based primarily upon organoleptic tests upon the baked and candied material, prepared by methods as closely standardized as it was possible to make them. It was necessary to modify the method somewhat in preparing material that had been dried without curing, since such material absorbed water more slowly, required somewhat longer time to bake, and, because of its higher starch content and lower sweetness, required somewhat larger additions of sugar to give it equal palatability when candied than did material dried after curing.

In preparation of the samples for comparison, the dry material and various additions, such as butter, sugar, and salt, were accurately weighed and all water added was measured. It was apparent from various experiments that the amounts of these additions could be considerably varied without appreciably affecting the results. Ratings for quality were very largely determined by texture or consistency, presence and degree of starchiness or its absence, and character and intensity of flavor. Repeated tests showed that none of these characteristics were materially modified, much less obscured, by considerable variations in amount of the various additions made to a given quantity of the original dry material.

The general method followed in the preparation of the material was: The dry material was thoroughly washed in cold water, placed in a baking dish, covered with 1½ times its weight of cold water, the cover placed upon the dish, and placed in the oven at moderate temperature (325° to 375° F.) for 1 hour in the case of material cured previous to drying, or for 1½ hours for the uncured material. Additional water up to a total of twice the weight of the material was added during the process. At the end of the period butter and salt were added, the oven adjusted to baking temperature, and the cooking continued for 1½ hours in the case of material dried after curing, or for 2 hours for uncured material. The material was then thoroughly done and could be served as baked slices or strips. Material so treated was candied by sprinkling the slices with sugar, adding more butter, sprinkling with water, and returning to the oven until thoroughly browned.

For making French fried or sautéed sweetpotato, the strips or slices were refreshed in water in the oven in the manner described and then removed, drained, and fried in deep fat or in a well-greased pan, as desired. For making a pie filler or for serving as creamed sweetpotato, the slices, after being refreshed in the oven, were pulped with the addition of milk, butter, and spices, after which the material could be made into pies or returned to the oven and browned for serving.

The results of the examination and grading of the varieties are stated by assembling them into groups or ranks, the members of each group having the same general level of excellence, rather than by assigning each variety a numerical grade or score. This is done for several reasons, the most important of which is the fact, already pointed out, that the raw material varied somewhat from year to year as a result of seasonal conditions, treatment previous to drying, and other factors not under control, and that the differences so produced carried through and affected the quality of the final product. This was obvious as various lots of a given variety were studied from year to year. The consequence was that of a group of several varieties, a different one might appear to be slightly superior to the others in every different year. Also, the factors upon which the ratings for quality chiefly depend are matters of personal preference, not subject to standardization. For these reasons, the varieties are grouped into ranks. The differences in quality and general desirability existing between the successive ranks are distinct and unmistakable; at the same time the latitude within the individual rank is sufficient to take account of the variability in material occurring as a result of differences in conditions of growth, in handling subsequent to harvest, and other uncontrollable factors.

## GRADING OF COLOR AND APPEARANCE OF THE DRY MATERIAL

The range of colors presented by the material in the dry state extended from ivory white through various shades of yellow and of yellow intermixed with red to deep orange or amber, with various degrees of admixture of brown with yellow and red. Comparison of the material with the same varieties in the fresh condition or in canned form, or with the color plates made from canned material which are presented in the publication of Magoon and Culpepper (*31*), showed no agreement, for the reason that all varieties show an intensification of color as compared with either the fresh or the canned material. A moderate degree of success in matching the colors of the different varieties in the dry condition with the color plates of Ridgway (*38*) was attained, and the values are included in table 3.

The judges were asked to score the various samples in the dry condition on the basis of uniformity and attractiveness of color. It was found by comparing the results that all the judges considered the lighter colors—dull white through ivory yellow and cream—as unattractive, that in the yellows, increase in depth and intensity of the color was considered increasingly attractive, and that mixtures of yellow and red, or pink, or yellow and orange were more attractive than most of the yellows. Some of the varieties were uniform clear yellow ranging in tint from apricot to light cadmium or deep lemon, and these were considered by most of the judges as attractive as the yellow reds. In general, a dull color was considered less attractive than a bright one, and the presence of browning was regarded as diminishing attractiveness.

Table 3.—*Comparative ranking of sweetpotato varieties in color and appearance of dry material*

| Variety | Rank as to productiveness[1] | Color of flesh in fresh sweetpotato | Color in the dried condition | | Rank on appearance, dried condition |
|---|---|---|---|---|---|
| | | | Dried before curing | Dried after curing | |
| Ballinger Pride | Fourth | Massicot yellow to ivory yellow | Brownish yellow to apricot | Light amber brown | Fair to good. |
| Big Stem Jersey | First | Amber yellow to straw yellow | Burnt sienna to Sanford's brown | Sanford's brown to auburn | Fair, rather dull. |
| Creola | Fourth | Straw yellow | Apricot yellow | Apricot to empire yellow | Fair to good. |
| Dooley | do | Straw yellow to flesh color | Medium orange | Rather deep orange | Very good. |
| Early Red Carolina | do | Cream to mustard yellow, carroty mottling. | Browned golden yellow | Golden yellow, browned | Good. |
| Florida | Third | Dull reddish to orange yellow | Amber brown | Amber brown to Sanford's brown | Fair to good. |
| Gold Skin | Fourth | Straw yellow to salmon buff | Golden yellow, red tinged | Reddish golden yellow | Very good. |
| Japanese "yam" | First | Cream, nearly white | Hazel to amber brown | Kaiser brown to cinnamon brown | Fairly good. |
| Key West "yam" | Fourth | Apricot yellow to empire yellow | Bright amber brown | Bright amber brown to Sanford's brown. | Very good. |
| Mameyita | Third | Deep bright reddish yellow | Amber to burnt sienna | Amber to burnt sienna, bright | Excellent. |
| Miles "yam" | do | Pale massicot yellow | Brownish yellow | Dull brownish yellow | Fair to good. |
| Myers' Early | do | Orange yellow | Mars orange to orange rufous | Burnt sienna to Kaiser brown | Beautiful. |
| Mullihan | do | Straw to flesh color | Mottled reddish yellow | Burnt sienna to Mars orange | Very attractive. |
| Nancy Hall | do | Straw to flesh, mottled with pink | Sanford's brown to Mars orange | do | Do. |
| Norton | Fourth | Light yellow | Grayish white to buckthorn brown. | Amber to Sudan brown | Good, attractive. |
| Porto Rico | Second | Carrot red to flesh color, mottled with buff yellow. | Burnt sienna | Sanford's brown to burnt sienna | Good to very good. |
| Pumpkin "yam" | Fourth | Carrot red to salmon, with ivory mottling. | Yellow to reddish yellow | Carrot red to yellow | Very good. |
| Red Bermuda | Second | Cream to apricot yellow | Sanford's brown to Mars orange | Bright amber to burnt sienna | Translucent, very attractive. |
| Red Brazil | do | Massicot yellow | Amber brown | Clear, deep amber brown | Very good to excellent. |
| Red Jersey | Fourth | Cream to mustard yellow, carrot red mottling. | Golden yellow, browned | Golden yellow, browned | Good to very good. |
| Southern Queen | Second | Massicot yellow | Brownish yellow | Brownish yellow | Fair to good. |
| Triumph | Fourth | Ivory yellow | Light amber to Mikado brown | Hazel to antique brown | Good. |
| Vineland Bush | Third | Reddish yellow | Sanford's brown | Light amber brown | Attractive, good. |
| Vineless Pumpkin "yam." | Fourth | Straw yellow to flesh ocher | Medium yellow | Yellow to orange | Very attractive. |
| Yellow Jersey | Third | Colonial buff to salmon | do | Golden yellow | Good, attractive. |
| Yellow Strasburg | Second | Massicot yellow | Auburn to Mikado brown | Prout's brown to slightly darker | Fair to poor. |

[1] Data furnished by J. H. Beattie. Varieties ranked in 4 groups in order of decreasing yields.

### GENERAL APPEARANCE IN DRY CONDITION

Under this designation were recorded the general impressions given by factors other than color, including degree of opacity or translucency, uniformity in size and shape of pieces, of shrinkage or distortion of pieces, of prominence of vascular bundles, and any other characteristics that might add to, or detract from, the appearance of the material. It was, of course, necessary to differentiate between effects of accidental variations in details of treatment of the various samples and features of appearance inherent in the variety, but it is felt that this was successfully done. The results of the examination and grading of the dry material are presented in table 3.

### TEXTURE AND CONSISTENCY OF COOKED PRODUCT

Each of the judges, in judging the cooked products, had a twofold undertaking involving a considerable degree of familiarity with the fresh material. They were asked to measure the flavor and quality of the products made from the dry material against their conception of corresponding products made from fresh material of the variety, to decide in how far drying had affected the quality of the material, and then to compare the various dried products between themselves. The ideal method of judging the material would have been to have cooked samples of fresh material of each variety for comparison, but this was not always possible.

It was not possible to establish any single common standard of quality with which the various lots might be compared. Some of the judges preferred the firm, mildly sweet types of sweetpotato, others the moist, soft, melting, highly sweet types. The material presented the whole range of differences in consistency and apparent sweetness to be found in sweetpotatoes, and it was consequently necessary to separate the material into soft and firm types and to judge a given variety by comparison with others of its type. This enabled the judges, despite their individual preferences, to evaluate differences in texture and smoothness of the pulped product, in degree of disintegration when candied or sautéed, in prominence of vascular bundles, and other varietal differences.

### FLAVOR

Judgments on flavor differed widely with individuals, but the differences centered chiefly between the cured and uncured stocks. The products made from uncured sweetpotatoes as a whole were low in sugar content and had little distinctive varietal flavor, so that it was sometimes impossible to be certain of the variety or even of the varietal group of a sample on the basis of its flavor. After curing, the increase in sweetness is accompanied by a rather pronounced intensification of flavor which frequently enables one to recognize the variety. Some preferred the products from uncured sweetpotatoes, while others considered them characterless and uninviting as compared with those from the cured material. By separating the products from cured and uncured stock and regarding them as distinctive groups, the judges were enabled to reach essential agreement as to the rank of most varieties regardless of differences in their individual preferences.

## COMPARATIVE SUITABILITY OF VARIETIES FOR DRYING PURPOSES

The rank of a variety with respect to the quality of the dried product made from it was determined by averaging together the detailed ratings given the dry material on appearance and color and those given the dish made from it on color and degree of attractiveness, texture, palatability, and flavor. The general average for each variety was expressed in one of the six terms—excellent, very good, good, fair, poor, and very poor.

The quality of the product, however, is by no means the only factor considered in determining the desirability of a variety as material for drying purposes. Other factors having considerable weight are the comparative ease or difficulty of preparation, the tendency to discoloration, the amount of loss in peeling, the labor involved in trimming, and field and storage characters, such as productiveness, susceptibility to disease in the field or in storage, and the like. Some of these may easily be of such importance when unfavorable in character as to make it inadvisable to attempt the use of a variety for drying purposes even though the product made from it may be of acceptable character. For this reason an attempt has been made to take into account all the factors having a bearing upon the relative desirability of the different varieties for drying purposes and to indicate them in the statement of results of grading the dried products.

In pursuance of this plan, the varieties have been assembled into two groups as desirable or suitable and undesirable or unsuitable. In assigning varieties to one or the other group, all varieties that made dried products grading excellent to fair in appearance and table quality, that were reasonably free from such defects as undesirable shape or proneness to discoloration, and that also seemed sufficiently productive and resistant to common field and storage diseases to have possibilities as commercial varieties were placed in the group designated as desirable. The varieties classed as undesirable or unsuitable for drying purposes were those yielding products very poor or unacceptable in appearance and quality, those in which the shape and form of the roots caused excessive loss in preparation, and those so unproductive or so susceptible to disease as to make their cultivation inadvisable.

### VARIETIES CONSIDERED SUITABLE OR DESIRABLE

The group considered desirable for drying purposes consisted of 26 named varieties. It presented a rather wide range in quality, since it included all the varieties rated as excellent to fair on the quality of their dried product and which were at the same time acceptable with respect to productiveness, disease resistance, and related factors determining desirability for the grower. Table 3 contains data as to productiveness, color of flesh, and color and general appearance and degree of attractiveness of the dried product; table 4 presents the results of grading of the baked and candied products and assigns each variety to a comparative rank on the basis of these results.

TABLE 4.—*Comparative ranking of sweetpotato varieties in quality of cooked product*

| Variety | Character of cooked product | | | | | | Final ranking |
|---|---|---|---|---|---|---|---|
| | Baked | | | Candied | | | |
| | Color | Texture | Flavor | Color | Texture | Flavor | |
| Ballinger Pride | Amber, darkened | Medium firm | Fair | Brown, darkened | Fair to good | Fair | Fair, fourth rank. |
| Big Stem Jersey | Yellowish brown to dark brown. | Fair, no starchiness. | Fair to good | Yellowish to dark brown. | Very good, tender but holds shape. | Good to very good | Good to very good, second rank. |
| Creola | Amber brown | Fair, medium firm | Fair | Dark amber brown | Fair | Good | Fair to good, third rank. |
| Dooley | Deep orange | Good | Fair to good | Deep orange | Good | do | Good, third rank. |
| Early Red Carolina | Golden brown | Fair | Very good | Deep golden brown | Very good | do | Do. |
| Florida | Good | Too firm, starchy | Fair, mild | Good amber brown | Firm, rather tough | do | Good, fourth rank. |
| Gold Skin | Reddish, golden, good. | Good | Fair to good | Browned golden yellow. | Fair to good | do | Good, typical Jersey, third rank. |
| Japanese "yam" | Light reddish brown. | Good; no starchiness. | Very good | Medium reddish brown. | Very good to excellent. | Very good | Good, third rank. |
| Key West "yam" | Dark reddish brown. | Good; rather firm | do | Golden yellow-brown, attractive; good. | Slightly firm | Good | Do. |
| Mameyita | Good. Yellow-brown. | Good; rather melting. | do | Golden yellow-brown, attractive. | Excellent; tender but holds shape. | Excellent | Excellent, first rank. |
| Miles "yam" | Brownish yellow, darkened. | Medium firm | Fair | Brown, darkened | Medium firm, fair | Fair | Fair, fourth rank. |
| Myers' Early | Light brownish yellow, very attractive. | Very good | Excellent | Near Kaiser brown | Excellent, no toughness nor starchiness. | Excellent | Excellent, first rank. |
| Mullihan | Amber brown, mottled. | do | Good to very good | Deep amber | Very good | Very good | Very good to excellent, first rank. |
| Nancy Hall | do | do | do | Amber brown | do | Excellent | Excellent, first rank. |
| Norton | Brownish yellow, good. | Very good, slightly starchy. | Agreeable | Brownish yellow, considerably darkened. | Soft, disintegrated | Good; not pronounced. | Fair, fourth rank. |
| Porto Rico | Dark reddish brown. | Very good, tender and melting. | Excellent | Deep yellowish to brownish red. | Very good; tender but keeps shape. | Good to very good | Good, second rank. |
| Pumpkin "yam" | Browned yellowish red. | Good, tender | Good | Browned yellowish red. | Good, soft | Good | Good, third rank. |
| Red Bermuda | Very good, reddish yellow. | Fair to good | Acceptable; not outstanding. | Very good | Good | do | Good, second rank. |
| Red Brazil | Brownish yellow | Firm, somewhat starchy. | Fair | Dark brownish yellow. | Rather dry, tough | Mild; not outstanding. | Fair, fourth rank. |

TABLE 4.—*Comparative ranking of sweetpotato varieties in quality of cooked product*—Continued

| Variety | Character of cooked product | | | | | | Final ranking |
|---|---|---|---|---|---|---|---|
| | Baked | | | Candied | | | |
| | Color | Texture | Flavor | Color | Texture | Flavor | |
| Red Jersey | Browned golden yellow. | Fair, medium firm. | Very good | Deep golden brown. | Very good | Good | Good, third rank. |
| Southern Queen | Dark brownish yellow. | do | Fair | Dark brown | Fair | Fair | Fair to good, fourth rank. |
| Triumph | Yellowish brown | Fair to good | Fair to good | Yellowish brown | Fair to good | Fair to good | Do. |
| Vineland Bush | Light brownish yellow. | Fair, rather firm | Good | Brownish yellow, fair. | Good | Good | Good, third rank. |
| Vineless Pumpkin "yam" | Brownish yellow to orange. | Fair | do | Browned orange yellow. | Fair | do | Do. |
| Yellow Jersey | Golden brown | Good; firm but tender. | do | Deep golden brown. | Good | do | Good; typical Jersey, second rank. |
| Yellow Strasburg | Reddish brown, good. | Good; somewhat firm. | Very good | Deep reddish yellow to reddish brown. | Very good | Excellent | Excellent, second rank. |

### FIRST RANK, OR EXCELLENT

All factors considered, Nancy Hall, Myers' Early, Mullihan, and Mameyita were slightly superior to all others. They combine attractive appearance and deep bright color in the dry state with attractive color, freedom from an objectionable degree of darkening in cooking, moderately firm texture, freedom from toughness or starchiness, and outstanding flavor when baked or candied. Myers' Early and Mullihan are believed to be selected strains of Nancy Hall, and this is borne out by the identity in texture, appearance, and quality of dishes made from the three varieties. Mameyita is a comparatively recent introduction which has all the desirable characters just enumerated for Nancy Hall and is equally productive and reasonably resistant to disease.[5]

### SECOND RANK, OR VERY GOOD

Big Stem Jersey, Yellow Jersey (and the apparently identical Little Stem Jersey), Yellow Strasburg, Porto Rico, and Red Bermuda make up the second-rank group, the members of which in most respects very nearly equal those of the first rank. Red Bermuda was somewhat the most attractive of all the varieties studied in the dried condition by reason of its very uniform, deep bright amber color, but was rather soft in texture and not quite equal to the first-rank varieties in flavor. The dried material of Yellow Strasburg was not especially attractive, being rather dark brown, but the cooked products were very good in color and texture and excellent in flavor. Porto Rico was equal to the first-rank varieties in most respects, but became somewhat dark and rather soft on baking or candying.

Yellow Jersey had a somewhat brighter golden-yellow color than Big Stem Jersey, both in the dried condition and after preparation for the table; both were somewhat firm, but were without toughness or starchiness and had excellent flavor. None of the members of the group present any especial difficulties in preparation for drying except Porto Rico, which has a somewhat higher loss in peeling due to irregularities in shape.

### THIRD RANK, OR GOOD

All the varieties placed in the third-rank group have sufficient attractiveness in color and appearance in the dry state to make them acceptable for consumption, but as a group they are not equal to the second-rank varieties in smoothness and fineness of texture when cooked, and few if any of them are equal in flavor. The group includes Red Jersey and the apparently identical Early Red Carolina, Gold Skin, and Vineland Bush, all of which are members of the Jersey group, with Creola, Dooley, Key West "yam," Pumpkin "yam," Vineless Pumpkin "yam," and Japanese "yam."

It will be noted that Big Stem Jersey and Yellow Jersey were placed in the second-rank group, while four additional members of the Jersey group are placed in the third-rank group. The varieties of the Jersey group have a great many similarities in vine and root characters, which make the group a very distinct, well-marked one. There is like similarity in the dried products from them, both in the dried state and when prepared for the table. While differing somewhat in depth and quality of color in the dried condition, Red Jersey, Gold Skin, and Vineland Bush were all very attractive and compared somewhat favorably with Big Stem Jersey and Yellow Jersey.

---

[5] Personal communication from J. H. Beattie.

None of the above varieties gave any special difficulty in preparation for drying, and none darkened objectionably in preparation for the table. The baked and candied products made from the four varieties were nearly or quite indistinguishable in color, texture, and flavor, but were alike in being too firm and mealy in texture, and acceptable but not outstanding in palatability and flavor. They are placed in a rank below Big Stem Jersey and Yellow Jersey because they are not quite equal to these varieties in table quality.

Creola and Key West "yam" yielded products nearly identical in texture and flavor, that from Key West "yam" being slightly firmer. Both were firmer in texture and not quite equal in flavor to Porto Rico or Red Bermuda. They were also a little less attractive in color than these varieties, both in the dry state and after preparation for the table. The four varieties are closely related, all being of the bush section of the Spanish group, with many similarities, but Porto Rico and Red Bermuda seem to be slightly superior in nearly every respect as material for drying purposes.

Dooley and Pumpkin "yam" made cooked products very similar in quality, rather soft in texture, and somewhat squashlike in flavor. Dooley was somewhat more pleasing in color in the dry state, but the two were equally attractive when prepared for the table. Vineless Pumpkin "yam" and Japanese "yam" made products of very attractive appearance, fairly firm texture, and very good flavor.

### FOURTH RANK, OR FAIR

The differences between the first three groups are rather small, and many of them would not be obvious on first examination and sampling of the material. The gap between the fourth-rank group and the preceding one is considerably greater than that between groups 3 and 2 or between groups 2 and 1. The group consists of Southern Queen, Ballinger Pride (which is apparently identical in all respects with Southern Queen), Miles "yam" (which appears to be an inferior strain of Southern Queen), Florida, Norton, Red Brazil, and Triumph.

Most of these are less attractive in the dried condition than the members of the last group because of the predominance of dull brown or amber in their colors, although none would be rejected on the score of color. Their defects are not so much in appearance as in the quality of the cooked material. Southern Queen and the apparently identical Ballinger Pride darken rather badly and soften and lose shape in cooking, but are fair to good in flavor. Miles "yam" had the same defects in more pronounced degree and by most of the judges was considered not equal in flavor to Southern Queen. It was also less attractive in the dried state because of its dull brownish-yellow color. Florida and Norton had very good appearance when dried, but darkened very considerably in cooking. All were too firm and starchy if dried prior to curing, while the cured material of Florida was somewhat firm and tough. Cured material of Norton became very soft and disintegrated badly when cooked. All three had mild and agreeable but not very pronounced flavor. Triumph was more attractive in color than Florida or Norton and underwent less darkening in preparation for the table, but was only fair in texture and flavor. Red Brazil was perhaps the most attractive of the group in the dried state, but was firm, starchy, and rather flavorless when prepared for the table.

Taken together, the varieties of this group make dried products sufficiently attractive in color and general appearance to be acceptable without question. Some of them require careful handling to prevent discoloration during preparation, notably Southern Queen, Florida, and Miles "yam," but this could be controlled by prompt dipping and adequate steaming. None of these varieties has inherent high quality as a fresh sweetpotato, and some of them have defects of texture and flavor that are quite apparent in the dried, cooked product. Consequently, while all of the group are acceptable, none of them can be rated as better than fair or mediocre in table quality. In view of the fact that the first three groups offer a choice of 19 varieties that yield products of equally good market appearance and distinctly higher table quality, it is doubtful whether attempts should be made to employ any of this group for making a commercial dried product.

### VARIETIES NOT SUITABLE OR PROMISING

As one of the purposes of this work was the determination of the possibilities as material for drying purposes of as many varieties and strains of sweetpotato as it was possible to secure, a very considerable amount of work was done with material shown, by the results obtained, to be definitely without promise. The total number of distinct varieties and strains so examined and condemned as unpromising is about 50. The greater part of these are unnamed varieties and strains of various origins that were under study in the variety collection, but which were shown by the field tests to be so lacking in productiveness or disease resistance or so inferior in quality to existing varieties that they have been discarded and are probably no longer in existence.

A considerable number were distinct named varieties, some of which are widely distributed but grown chiefly for home use; others are commercial sorts in certain districts, and still others are old varieties now in process of displacement by better sorts. Since these varieties are in some instances produced in considerable quantities, there is the possibility that attempts to employ them for drying purposes may be made. For this reason it seems advisable to list such unsuitable or unpromising varieties as are actually in cultivation, with a general recommendation that they be avoided for drying purposes and to indicate the reasons for such advice. This has been done in table 5 insofar as the limitations of tabular arrangement permit.

TABLE 5.—*Sweetpotato varieties unpromising for drying purposes*

| Variety | Color of flesh in fresh condition | Color of previously cured dry material | Appearance, dry | Quality of cooked products | Comments |
|---|---|---|---|---|---|
| Belmont | Ivory yellow | Apricot to massicot yellow | Fair | Fair to poor; darkens badly. Flavor and texture poor. | Not promising. Low yields in field tests. |
| Catawba White | do | Medium straw yellow | Fair to good | Fair to poor; darkens badly | Mediocre in appearance and quality; low yields. |
| Catawba Yellow | do | do | Good | Fair; darkens badly, poor flavor. | Small size and low yields; poor quality. |
| Dahomey | Marguerite yellow | Light straw yellow | Poor; bundles prominent. | Pale yellow; darkens badly | Poor shape; peeling losses excessive; poor quality. Heavy yields. |
| Early Carolina | Colonial buff to salmon | Salmon | Fair; pieces small | Fair; much darkening | Low yields, small size, only fair quality. |
| General Grant Vineless | Cream buff to cinnamon pink. | Pale cream buff, darkened | Good | Fair to good; rather dark | Low yields; only fair quality. |
| Georgia | Medium yellow to ivory yellow. | Apricot yellow | Fair to good | Poor flavor; darkens badly | Apparently identical with Belmont. Low yields. |
| Gros Grandia | Very pale cream-white | Cream yellow | Poor; bundles prominent, pieces small. | Poor; brownish-olive discoloration in baking. | Low yields, many strings, poor quality. |
| Haiti "yam" | Ivory yellow to flesh color | Apricot yellow | Fair to good | Moderately good | Poor shape, peeling losses excessive. Very heavy yields. |
| Pierson | Colonial buff to massicot yellow. | Reddish yellow | do | Very mediocre in flavor and texture. | Poor quality, high peeling losses. Moderate yields. |
| Purple "yam" (Nigger Choker) | Pale creamy white, stained with magenta to purple. | Very pale yellow | Poor | Mediocre to poor; very dark when baked. | Irregular shape, large peeling losses, poor quality. Fairly heavy yields. |
| White "yam" | Massicot yellow | Pale whitish yellow | do | Poor flavor and texture; darkens badly. | Irregular shape, many small potatoes, very poor quality. Poor yields. |
| Vineless "yam" | Ivory yellow, pinkish cinnamon blush. | Brownish yellow | Fair | Fair; darkens badly | Low yields, not outstanding in quality. |
| Yellow "yam" | Ivory yellow, cortex flesh colored. | Medium brownish yellow | Poor | Fair to poor; flavor poor, insipid. | Mediocre in all respects. Moderate yields. |

It may be noted that nearly all the varieties having very pale or white flesh that were used in the work are classed as undesirable for the purpose. As a rule, sweetpotatoes having flesh nearly devoid of pigment, as ivory, or creamy white, or white mottled with very pale yellow, make dry products that are oystershell-like or hornlike in color. Some darkening usually occurs in drying and is rendered much more apparent by the absence of color. Most of these varieties darken very considerably in preparation for the table, giving finished products that have a dull whitish-brown to olive-brown color. Varieties that combine pale, unattractive color in the dried condition with pronounced darkening in cooking are Belmont, Dahomey, Georgia (possibly identical with Belmont), General Grant Vineless, Gros Grandia, Purple "yam" (Nigger Choker), and White "yam." In all of these the dried material was so lacking in attractive color that it would not be readily accepted by consumers if more attractive material were available. Similar results were obtained with a number of unnamed introductions having white flesh.

A number of varieties are rather unpromising, regardless of quality, primarily because of irregularities in shape which make large losses in peeling and much hand labor in trimming unavoidable. Examples are such long, contorted, rootlike varieties as Purple "yam" (Nigger Choker), Gros Grandia, Japanese "yam," and highly irregular, deeply grooved varieties, such as Haiti "yam" and Pierson. The additional cost of preparation and the lower yields of dried products from the raw stock used would not be justified unless the variety were one which combined exceptionally high yield per acre with attractive market appearance and high quality of the dried product. None of the varieties just named has these qualities.

Work with a number of varieties was discontinued because they have consistently given such low yields or shown such a large percentage of very small sweetpotatoes or strings that they seem to have no commercial possibilities. Among these are Catawba White and Catawba Yellow (both of which appear to be inferior strains of Southern Queen), Early Carolina (apparently a much inferior strain of Yellow Jersey), Gros Grandia, General Grant Vineless, White "yam," and Vineless "yam." Many of these have already been named as having poor color or discoloring badly in preparation for the table, and none are sufficiently outstanding in quality to justify the expectation that they would find much favor with consumers.

A few varieties were without especially outstanding faults, but were consistently mediocre in all respects. Old Time "yam" and Yellow "yam" are examples. Both are fairly productive, not especially subject to disease, and have size and shape that permit preparation without excessive loss, but both are unattractive in color and appearance in the dry condition and after preparation for the table, and in flavor or texture they have nothing to recommend them.

## GROUP RELATIONSHIPS IN RELATION TO VARIETAL QUALITY

The more important American varieties of sweetpotatoes have been classified by Thompson and Beattie (*46*) into eight groups, each of which they considered as distinct and readily differentiated from others by characters of vine and root. In the preceding discussions and the accompanying tables varieties have been dealt with as individuals, with no more than incidental reference to their group relationships or positions in any scheme of classification. It would seem to be of considerable interest to study the varieties with respect to their group relations, in order to determine the extent to which the characters that make a variety good, mediocre, or unpromising for a given purpose are specific to the variety or common to all the group of which it is a member. Insofar as a search of the literature indicates, no one has given very detailed consideration to this point.

In their characterizations of the several groups, Thompson and Beattie (*46*) state the consistency, texture, and degree of sweetness characteristic of the members of the group when baked, but usually make no general statements as to the flavor or quality of the group. Such statements are included in descriptions of the baked products of the individual varieties. Magoon and Culpepper (*31*) described rather fully the quality of the canned product of each of the varieties included in their study, and evaluated their canning quality in terms ranging from very good to very poor, but did not make any comparisons between the groups.

It seems worth while to determine to what extent good or poor quality of a variety may be consistent when the results of baking, canning, and drying are compared, and also to ascertain to what extent varieties of the same group show consistent results when treated in this way. This has been done in table 6, in which the varieties used have been arranged in the groups and subgroups of the classification made by Thompson and Beattie. There are also given in parallel columns the baking quality as stated by these authors,[6] supplemented by the results of further unpublished work by Beattie, the canning quality as stated by Magoon and Culpepper (*31*), and the results of the present study of drying quality. A number of varieties used in this study and also in the work of Magoon and Culpepper, but which have not been named or assigned to groups, are also listed. In some instances several strains of a variety are included along with the variety, such as Ballinger Pride, Miles "yam," Catawba White, and Catawba Yellow with Southern Queen, for the reason that the various strains gave slightly different results or showed differences in suitability for the purposes concerned.

TABLE 6.—*Group relationships in relation to quality in dried, canned, or baked sweetpotatoes*

| Group | Quality for drying purposes | Quality when canned [1] | Quality when baked [2] |
|---|---|---|---|
| BELMONT GROUP | | | |
| Belmont section: | | | |
| Belmont | Poor, unsuitable | Poor to fair, medium soft, darkens. | Sweet, moist, soft. |
| Vineless Pumpkin "yam" | Good, third rank | Good, very soft | Very sweet, moist, fairly firm. |
| Old Time "yam" | Poor, unsuitable | Not used | Very sweet, moist, soft. |
| Yellow "yam" | do | Fair, medium soft | Fairly sweet, moist, firm, good texture. |
| Bunch section: | | | |
| Gros Grandia | do | Poor, medium firm, pronounced darkening. | Moist, poor in quality. |

[1] After Magoon and Culpepper (*31*).
[2] After Thompson and Beattie (*46*), with revision and expansion by J. H. Beattie.

---

[6] The authors are indebted to J. H. Beattie for revising and expanding statements as to baking qualities by inclusion of results of studies made by him subsequent to the publication by Thompson and Beattie (*46*).

TABLE 6.—*Group relationships in relation to quality in dried, canned, or baked sweetpotatoes*—Continued

| Group | Quality for drying purposes | Quality when canned | Quality when baked |
|---|---|---|---|
| SPANISH GROUP | | | |
| Yellow Spanish section: | | | |
| Pierson | Poor, unsuitable | Poor, medium firm, pronounced darkening. | Moist to dry and mealy, firm, only slightly sweet. |
| Yellow Strasburg | Very good, second rank. | Good, firm, little darkening. | Sweet, quite soft, moist, good quality. |
| Triumph | Fair, fourth rank | Fair to good, medium firm | Medium moist to dry, firm, fairly sweet, fair quality. |
| Bermuda section: | | | |
| Red Bermuda | Very good, second rank. | Fair to good, medium firm, pronounced darkening. | Dry, somewhat mealy, firm, only slightly sweet. |
| Red Brazil | Fair, fourth rank | do | Sweet, fairly mealy, good quality. |
| Porto Rico | Very good, second rank. | Very good, very soft | Moist, very sweet, excellent quality. |
| Key West | Good, third rank | Fair, soft, pronounced darkening. | Medium moist, fine texture, good quality. |
| Creola | do | Fair, very soft | Sweet, moist, fair quality. |
| Red Spanish section: | | | |
| Purple "yam" (Nigger Choker). | Very poor, unsuitable. | Poor, firm, pronounced darkening. | Very dry and mealy, only slightly sweet, poor quality. |
| Dahomey | Poor, unsuitable | Fair, pronounced darkening. | Dry, mealy, very sweet, only fair quality. |
| FLORIDA GROUP | | | |
| Florida | Fair, fourth rank | Poor, medium firm, pronounced darkening. | Sweet, moist, soft. |
| General Grant Vineless | Poor, unsuitable | do | Sweet, dry, mealy, medium firm, mottled yellow-white. |
| Nancy Hall | Excellent, first rank. | Very soft, good, little darkening. | Very sweet, moist, soft, excellent quality. |
| Mullihan | do | Good, soft, little darkening. | Not listed; considered identical with Nancy Hall. |
| SOUTHERN QUEEN GROUP | | | |
| White "yam" | Poor, unsuitable | Fair, very soft, pronounced darkening. | Sweet, dry, mealy, fairly firm. |
| Southern Queen | Fair, fourth rank | Fair, soft, pronounced darkening. | Sweet, moist, soft. |
| Miles "yam" | do | do | Considered identical with Southern Queen. |
| Ballinger Pride | do | do | Do. |
| Catawba White | Poor, unsuitable | do | Do. |
| Catawba Yellow | do | Fair, medium firm, pronounced darkening. | Do. |
| PUMPKIN GROUP | | | |
| Pumpkin "yam" | Good, third rank | Good, very soft | Very sweet, moist, soft; good quality of moist type. |
| Norton | Fair, fourth rank | Not used | Very sweet, moist, soft, melting, fair quality. |
| Dooley | Good, third rank | Good, soft to very soft | Soft, sweet, squashlike; good quality, of moist type. |
| JERSEY GROUP | | | |
| Red Jersey section: | | | |
| Red Jersey | do | Good, firm, little darkening. | Fairly sweet, dry, mealy, firm, yellow. |
| Early Red Carolina | do | Good, firm | Not used. |
| Bush section: | | | |
| Vineland Bush | do | Not used | Sweet, dry, mealy, firm, good quality. |
| Big Stem Jersey section: | | | |
| Big Stem Jersey | Very good, second rank. | Good, firm | Do. |
| Yellow Jersey section: | | | |
| Yellow Jersey | do | do | Very dry, mealy, firm, fairly sweet, good quality. |
| Gold Skin | Good, third rank | Very good, medium firm | Medium dry and mealy, firm, very sweet, good quality. |
| Early Carolina | Poor, unsuitable | Fair, pronounced darkening. | Not used. |

TABLE 6.—*Group relationships in relation to quality in dried, canned, or baked sweetpotatoes*—Continued

| Group | Quality for drying purposes | Quality when canned | Quality when baked |
|---|---|---|---|
| UNCLASSIFIED | | | |
| Haiti "yam" | Poor, unsuitable | Fair, medium firm. | Not used. |
| Mameyita | Excellent, first rank. | Firm, rather poor | Very moist, moderately sweet, deep yellow, compares favorably with the Porto Rico variety. |
| Vineless "yam" | Poor, unsuitable | Fair, soft, pronounced darkening. | Not used. |
| Japanese "yam" | Good, third rank | Poor to fair, soft, darkens. | Do. |

Inspection of table 6 indicates that there is a very considerable degree of similarity in the quality rankings of the several sweetpotato varieties belonging to any given group, whether determined by baking, canning, or drying. The Belmont group is characterized by Thompson and Beattie as one in which the baked products are very sweet, extremely moist to sirupy, soft but sometimes coarse and stringy in texture, and rather squashlike in flavor, all of which indicates absence of exceptionally high quality for baking. The group contains only one variety ranked as good for canning or drying, the others being termed fair to poor.

The members of the Spanish group show a fairly wide range in character when baked, from slightly sweet to very sweet, from moist to dry and mealy, and from soft to firm, the members of the Bermuda section apparently being regarded by Thompson and Beattie as especially good in quality. With two exceptions, all the Spanish group ranked fair to good or very good for canning purposes, and were equally good for drying.

For both canning and drying the members of the Bermuda section stand somewhat higher than those of the other sections. The varieties which gave poor and unsatisfactory results when dried—Pierson, Purple "yam," and Dahomey—are rather poor for all purposes because of undesirable shape, rather poor color, and more pronounced tendency to discoloration than is found in the other members of the Spanish group. The Florida group is a small one, with two varieties, Florida and General Grant Vineless, which rank only fair to poor for all purposes, and a third, Nancy Hall, which is of outstanding good quality for drying, canning, or baking. This high quality is also possessed by the rather closely similar strains, Mullihan and Myers' Early.

The Southern Queen group is made up of White "yam" and Southern Queen, with various more or less distinct strains or subvarieties of Southern Queen. All of these are of fairly good flavor when baked after proper curing and storage, but the rather coarse texture of the flesh and the presence of considerable quantities of fiber make them only fair as baked products. All are rather mediocre as canned or dried products, the strong tendency to discoloration detracting from the appearance of the material, while its coarse texture and the presence of fibers lowers its quality. The varieties of the Pumpkin group are very much alike in their moist, soft texture and distinctly sweet, somewhat squashlike flavor when baked. As canned products they are ranked as good. All made very acceptable dried products graded as fair to good.

The Jersey group as a whole stands somewhat higher than any of the others when the general quality of its members as baked, canned, or dried products is considered. Their dry, firm texture, sweetness, and good, rather appealing flavor give them good to excellent quality when baked, and these characters together with good color and comparative freedom from tendency to discoloration make them good for canning and good to very good for drying.

Considerable additional study of the quality of the various varieties as fresh products and after canning and drying will be necessary before any final evaluation of their value and usefulness can be made. From the information summarized in table 6, it is evident that the varieties studied show a very wide range in table quality, from excellent to very poor, and that the quality of a given variety remains rather consistently the same whether it is judged as a fresh product or after canning or drying. A variety which is of poor quality when fresh may be confidently expected to be still poorer after preservation by canning or drying. In some cases the variety may have acceptable texture and flavor and other characters, which give it good basic quality, but may be made less desirable for preserving purposes by size or shape which makes its preparation difficult or wasteful, but it must not be overlooked that like difficulty or waste will accompany its use in most forms as a fresh product. When this fact is given due weight, most varieties have rather uniform quality as fresh and as preserved material.

It is also clear that the groups and subgroups proposed by Thompson and Beattie (*46*) show very considerable differences in general levels of quality, for the reason that in most of the groups the various members of each are quite similar in quality. The members of the Jersey group, the Bermuda section of the Spanish group, and the Pumpkin group are rather consistently high in quality, in each case by reason of the possession of desirable characters which are present in nearly equal degree in all the members of the group.

In the Belmont and the Southern Queen groups there is equally consistent poor or mediocre quality because of the absence from all members of these groups of some of the characters essential to high quality. The other varietal groups, insofar as studied, appear to be rather less uniform in the quality of their members, apparently because the groups consist of varieties presenting greater differences in color, texture, and flavor of flesh, proneness to discoloration, and similar characters.

Enough has been said to direct attention to the wide range of difference in texture, palatability, flavor, and other factors constituting quality to be found in the more or less generally cultivated and widely distributed varieties of the sweetpotato. In future studies of sweetpotatoes the desirability of increased attention to these factors as of equal importance with such factors as productiveness, freedom from susceptibility to disease, good keeping quality, and desirable shape and color for market purposes should be apparent. If some attention is given in the future to the problem of quality, it should ultimately be possible to work out an inventory and evaluation of existing varieties and gradually to eliminate from cultivation those that are poorest in table quality and least promising as material for preservation by canning or drying.

## DISEASE RESISTANCE AS A FACTOR IN CHOICE OF VARIETIES

Choice of varieties for drying purposes in any particular locality will necessarily be restricted to those grown locally, which will be those that the accumulated experience of growers has shown to have a sufficient degree of resistance to diseases prevalent in the area to yield profitable crops. When the introduction of varieties not previously grown is under consideration, it becomes a matter of considerable importance to know the degree of resistance to disease they have been found to possess. Discussion of comparative resistance and susceptibility to disease is outside the province of this circular, but for the benefit of interested readers a very brief summary of the present state of knowledge may be given. The statements made are derived from various publications of Harter and his associates (*17*, *18*, *19*) and particularly from the monograph in which Harter and Weimer have assembled the results of studies of these diseases by themselves and others up to 1929 (*17*).

No instance of complete immunity of any variety to any one of the more important diseases is known. In varieties found to have rather high resistance to a particular disease, it has been found that the degree of resistance varies from season to season and from district to district, with the result that generalizations are difficult. Comparative studies over a long period and under rather widely varied conditions have shown that some of the generally grown commercial varieties have a sufficient degree of resistance to the more important diseases to enable their successful cultivation in spite of the presence of these diseases; others are so susceptible that attempts to grow them in heavily infested areas would be disastrous. Some of the results of comparative studies of susceptibility to particular diseases are as follows:

Soil rot or pox (*17*).—No varieties are wholly resistant; those with red skins are generally more resistant than those with white or yellow skins.

Fairly highly resistant varieties: Red Bermuda, Red Brazil, Dahomey.

Moderately resistant: Pierson, Southern Queen, Yellow Strasburg, Red Jersey, Triumph, Florida, Yellow "yam," and White "yam."

Very susceptible: Big Stem Jersey, Nancy Hall, Porto Rico, Pumpkin "yam," Dooley, Yellow Jersey, and General Grant Vineless.

Stem rot or wilt (*19*).—Nearly immune or highly resistant: White "yam," Red Brazil, Triumph, Pumpkin "yam," Creola, Dahomey, Southern Queen, Yellow Strasburg, Haiti "yam," Key West "yam."

Extremely susceptible: Yellow Jersey, Big Stem Jersey, Red Jersey, Nancy Hall, Porto Rico, Gold Skin, Georgia, and Belmont.

Black rot (*18*).—All the 21 varieties tested were susceptible in some degree. Big Stem Jersey, Creola, Dahomey, Dooley, General Grant Vineless, Gold Skin, Haiti "yam," Key West "yam," Pierson, Pumpkin "yam," Red Brazil, Southern Queen, Triumph, Yellow Jersey, and Yellow Strasburg showed somewhat less disease at digging time than Porto Rico, Nancy Hall, Georgia, and Belmont. The Jersey group as a whole was somewhat less susceptible than others.

White rust (*17*).—Highly susceptible: Red Jersey, Yellow Jersey, Red Bermuda, and Nancy Hall.

Quite susceptible: Creola, Dooley, Big Stem Jersey, Florida, General Grant Vineless, Pierson, Yellow Strasburg, Red Brazil, Dahomey, and Yellow "yam."

Moderately susceptible: Porto Rico, Southern Queen, Key West "yam," and White "yam."

Slightly susceptible: Triumph, Belmont, Pumpkin "yam," and Vineless Pumpkin "yam."

Scurf (*17*).—All varieties tested, including all those mentioned above with some others and some unnamed selections, were susceptible. Apparently varieties differ very little in their degree of susceptibility.

Foot rot (*17*).—Little difference between varieties in their degree of susceptibility was noted.

Internal break-down (a condition developing in storage as a result of storage at high temperature combined with low humidity).—No detailed comparative studies under controlled conditions have been made, but it is known that Southern Queen and the members of its group are more susceptible than other varieties.

## SUMMARY

A method of drying the sweetpotato in slices or strips, which may subsequently be prepared for the table in a considerable variety of ways, has been developed. In outline, the method consists in careful inspection of the stock to eliminate decayed roots, peeling by abrasive machine or by immersion in hot lye solution of appropriate strength, washing and trimming, slicing or cutting into longitudinal strips by hand or machine, immersing in dilute citric acid solution to prevent darkening, spreading on trays, exposing to live steam for a sufficient period to rather completely cook the material, and drying at a temperature ranging between 130° to 165° F. to a residual moisture content of 12 to 15 percent. Sweetpotatoes may be dried directly from the field as dug or after previous curing and storage; the products made from cured and uncured stock of the same variety will differ considerably in sweetness, depth of color, and firmness of texture when prepared for the table and will require slightly different treatment in cooking, but will be of like quality.

When dried by the method here described, the material had a semitransparent or translucent appearance, a greatly intensified and deepened color as compared with the fresh raw sweetpotato, and a smooth, varnishlike surface due to the presence of a film of dry dextrins and sugars. At a residual moisture content of 12 to 15 percent the pieces were hard, hornlike, broke with a glasslike fracture under pressure, were not hygroscopic, and did not lose or gain in weight appreciably when stored for long periods with access of air. The material was very readily refreshed in preparation for cooking by soaking in cold water or, preferably, by placing in hot water and holding at simmering temperature for 1 to 1½ hours. After being refreshed, it could be prepared for the table as baked or candied sweetpotato, or as a mashed or pulped baked sweetpotato, or it could be pulped and employed in the making of pies or prepared as French fried or sautéed sweetpotato. The fact that the slices or strips could be prepared for use in a variety of ways made their preparation preferable to that of a granulated or riced product, which was also successfully prepared. The preparation of the riced product was more laborious and control of discoloration considerably more difficult; the product was rather strongly hygroscopic and required protection against access of air to prevent spoilage; it could be used only in a limited number of ways. It is consequently considered less useful than the other forms of product.

The dry material in sliced or strip form is not hygroscopic and does not require moisture-proof containers for storage. If dried to a proper moisture content and stored in storage rooms in which temperature and moisture content of the air are reasonably well controlled, the material may be kept for years without deterioration in appearance or table quality. It is not attractive to the ordinary insects attacking dried fruit, but is rather highly so to some of the small grain weevils and cigarette or drug-store beetles, so that containers used for packing and storage must be such as will effectively exclude these insects.

About 70 varieties, subvarieties, and strains of sweetpotatoes, including practically all the obtainable named varieties of any value or importance and a considerable number of unnamed introductions and selections, have been rather carefully studied as to their possibilities as material for making dried products. The work was continued over a number of years so as to eliminate variations in raw material due to seasonal conditions or other uncontrolled factors. The material was dried both as it came from the field at digging time and also after the usual curing, followed by a period of storage. Data as to loss in peeling and preparation and yields in terms of fresh stock and as percentages of peeled, trimmed stock are presented.

The dried products were carefully examined and graded in the dry condition for color and general appearance as dry products and were then prepared for the table in various forms that were again examined and graded for color, texture, flavor, and palatability as prepared products. The results were assembled and the varieties were ranked into groups of approximately equal merit in respect to quality. In the final ranking of the varieties, due weight was given to such factors as ease or difficulty of preparation for drying, percentage of loss in preparation, and the like.

Nancy Hall, Myers' Early, Mullihan, and Mameyita were somewhat superior in quality of product to all others. They were rather closely followed by a second group made up of Big Stem Jersey, Yellow Jersey, Porto Rico, Yellow Strasburg, and Red Bermuda, all of which make products that are very good in all respects, but not quite equal to the first group. A third group, graded good in quality, consisted of Red Jersey and Early Red Carolina, Vineland Bush, Gold Skin, Creola, Dooley, Key West "yam," Pumpkin "yam," and Vineless Pumpkin "yam." A fourth group, which made quite acceptable products and was graded fair in quality, contained Southern Queen and its strains—Ballinger Pride and Miles "yam," Florida, Norton, Red Brazil, and Triumph. Many of these were equal to varieties in the higher groups in appearance of the dried product, but were inferior to them as cooked products.

For various reasons the remainder of the varieties studied are considered unpromising material for drying purposes. In some cases the cause is inherently low quality in the variety; in others, unfavorable shape and size, which make preparation difficult and wasteful of material and labor; in still others, low productiveness and susceptibility to field and storage diseases. The varieties of the first three groups offer a rather wide range of material free from defects of this character, to which use for drying should be confined. Attention is called to the facts that the existent varieties of sweetpotatoes present a wide range in quality and that the quality of the individual variety is fairly consistent as prepared for the table from fresh material or after canning or drying. Increased attention to the factors constituting quality as at least of equal importance with productiveness and disease resistance in future studies of the sweetpotato is suggested as an effective method of eliminating low-grade and inferior varieties from cultivation and improving the quality and possibly increasing the consumption of the crop.

## LITERATURE CITED

(1) Balch, R. T., and Paine, H. S.
1931. PRODUCTION OF STARCH FROM SWEETPOTATOES, INCLUDING COMMENTS REGARDING MANUFACTURE OF WHITE POTATO STARCH. Indus. and Engin. Chem. 23: 1205–1213.
(2) Bennett, R. L.
1891. SWEETPOTATOES, TESTS OF VARIETIES, ANALYSES OF VARIETIES . . . Ark. Agr. Expt. Sta. Ann. Rept. (1890) 3: 123–128.
(3) Caldwell, Joseph S.
1923. EVAPORATION OF FRUITS U. S. Dept. Agr. Bull. 1141, 64 pp., illus.
(4) Carver, G. W.
1918. HOW TO MAKE SWEET POTATO FLOUR, STARCH, BREAD AND MOCK COCOANUT. Ala. Tuskegee Agr. Exp. Sta. Bull. 37, 6 pp.
(5) Christie, A. W., and Ridley, G. B.
1923. CONSTRUCTION OF FARM DEHYDRATERS IN CALIFORNIA. Jour. Amer. Soc. Heating and Ventilating Engin. 29: 687–716, illus.
(6) Culpepper, C. W., and Magoon, C. A.
1926. THE RELATION OF STORAGE TO THE QUALITY OF SWEET POTATOES FOR CANNING PURPOSES. Jour. Agr. Research 33: 627–643, illus.
(7) Cruess, W. V.
1924. COMMERCIAL FRUIT AND VEGETABLE PRODUCTS; A TEXTBOOK FOR STUDENT, INVESTIGATOR AND MANUFACTURER. 530 pp., illus. New York.
(8) ——— and Christie, A. W.
1921. SOME FACTORS OF DEHYDRATER EFFICIENCY. Calif. Agr. Exp. Sta. Bull. 337, pp. [277]–298, illus.
(9) ——— Christie, A. W., and Flossfeder, F. C. H.
1920. THE EVAPORATION OF GRAPES. Calif. Agr. Expt. Sta. Bull. 322, pp. [421]–471, illus.
(10) Gardner, Wright A.
1925. PHYSIOLOGY OF SWEET POTATOES. Ala. Agr. Expt. Sta. Ann. Rept. 36: 10–11, 1925; 38: 16–17, 1927.
(11) Gore, H. C.
1920. OCCURRENCE OF DIASTASE IN THE SWEET POTATO IN RELATION TO THE PREPARATION OF SWEET POTATO SIRUP. Jour. Biol. Chem. 44: 19–20.
(12) ———
1921. PREPARATION OF SWEET POTATO SIRUP. Chem. Age 21: 151–153, illus.
(13) ———
1923. FORMATION OF MALTOSE IN SWEET POTATOES ON COOKING. Indus. and Engin. Chem. 15: 938–940.
(14) ——— Reese, H. C., and Reed, J. O.
1923. PRODUCTION OF SIRUP FROM SWEET POTATOES. U. S. Dept. Agr. Bull. 1158, 34 pp., illus.
(15) Hand, T. E., and Cockerham, K. L.
1921. THE SWEET POTATO, A HANDBOOK FOR THE PRACTICAL GROWER, 261 pp., illus. New York.
(16) Harrington, H. H.
1895. WATER AND SUGAR IN SWEET POTATOES AS INFLUENCED BY KEEPING. Tex. Agr. Expt. Sta. Bull. 36: 628–629.

(17) Harter, L. L., and Weimer, J. L.
1929. A monographic study of sweet-potato diseases and their control. U. S. Dept. Agr. Tech. Bull. 99, 118 pp., illus.

(18) ———, Weimer, J. L., and Lauritzen, J. I.
1926. The comparative susceptibility of sweet-potato varieties to black rot. Jour. Agr. Research 32: 1135–1142.

(19) ——— and Whitney, W. A.
1927. The comparative susceptibility of sweet-potato varieties to stem rot. Jour. Agr. Research 34: 915–919, illus.

(20) Hasselbring, Heinrich.
1918. Behavior of sweet potatoes in the ground. Jour. Agr. Research 12: 9–17, illus.

(21) ———
1918. Effect of different oxygen pressures on the carbohydrate metabolism of the sweet potato. Jour. Agr. Research 14: 273–284.

(22) ——— and Hawkins, Lon A.
1915. Physiological changes in sweet potatoes during storage. Jour. Agr. Research 3: 331–342.

(23) ——— and Hawkins, Lon A.
1915. Respiration experiments with sweet potatoes. Jour. Agr. Research 5: 509–517.

(24) ——— and Hawkins, Lon A.
1915. Carbohydrate transformations in sweet potatoes. Jour. Agr. Research 5: 543–560.

(25) Johnson, Maxwell O.
1918. Drying as a method of food preservation in Hawaii. Hawaii Agr. Expt. Sta. Ext. Bull. 7, 31 pp., illus.

(26) Johnstone, George R.
1925. Physiological study of two varieties of Ipomoea batatas. Bot. Gaz. 80: 145–167, illus.

(27) Keitt, T. E.
1909. Sweet potato work in 1908. S. C. Agr. Expt. Sta. Bull. 146, 21 pp.

(28) ———
1911. The formation of sugars and starch in the sweet potato. S. C. Agr. Expt. Sta. Bull. 156, 14 pp.

(29) ———
1912. Sweet potato investigation. S. C. Agr. Expt. Sta. Bull. 165, 43 pp.

(30) McDonnell, C. C.
1908. The manufacture of starch from sweet potatoes. S. C. Agr. Expt. Sta. Bull. 136, 50 pp., illus.

(31) Magoon, C. A., and Culpepper, C. W.
1922. A study of sweet-potato varieties, with special reference to their canning quality. U. S. Dept. Agr. Bull. 1041, 34 pp., illus.

(32) ——— and Culpepper, C. W.
1924. Scalding, precooking, and chilling as preliminary canning operations. U. S. Dept. Agr. Bull. 1265, 48 pp.

(33) Mangels, C. E., and Prescott, S. C.
1921. Manufacture of sweet potato flour by the "flake" process. Chem. Age 29: 132–135, illus.

(34) Massey, W. F.
1894. Evaporated sweet potatoes. N. C. Agr. Expt. Sta. Bull. 96: 78.

(35) Miyake, K.
1915. On the nature of the sugars found in the tubers of sweet potatoes. Jour. Biol. Chem. 21: 503–506.

(36) Newman, J. S., and Pickett, J. Sam.
1902. New method of preserving sweet potatoes. S. C. Agr. Expt. Sta. Bull. 71, 6 pp.

(37) Nichols, P. F., Powers, Ray, Gross, C. R., and Noel, W. A.
1925. Commercial dehydration of fruits and vegetables. U. S. Dept. Agr. Bull. 1335, 40 pp., illus.

(38) Ridgway, Robert.
1912. Color standards and color nomenclature. 43 pp., illus. Washington, D. C.

(39) Shiver, F. S.
1897. THE SWEET POTATO AS A STARCH PRODUCER. S. C. Agr. Expt. Sta. Bull. 28, 15 pp.
(40) ———
1897. THE DETERMINATION OF STARCH IN THE SWEET POTATO. S. C. Agr. Expt. Sta. Bull. 30, 11 pp.
(41) ———
1901. SWEET POTATO. S. C. Agr. Expt. Sta. Bull. 63, 37 pp.
(42) Shuey, G. A.
1932. NEW USES FOR THE SWEET POTATO. SWEET POTATO JELLY. Tenn. Agr. Expt. Sta. Cir. 43, 2 pp.
(43) ———
1934. NEW USES FOR THE SWEET POTATO. SWEET POTATO SIRUP. Tenn. Agr Expt. Sta. Cir. 46, 4 pp.
(44) Stone, W. E.
1890. ZUR KENNTNISS DER KOHLENHYDRATE DER SÜSSKARTOFFEL (BATATAS EDULIS). Ber. Deut. Chem. Gesell. 23: 1406–1408.
(45) Thelen, Rolf.
1923. KILN DRYING HANDBOOK. U. S. Dept. Agr. Bull. 1136, 64 pp., illus. (Revised, 1929, 96 pp., illus.)
(46) Thompson, H. C., and Beattie, James H.
1922. GROUP CLASSIFICATION AND VARIETAL DESCRIPTIONS OF AMERICAN VARIETIES OF SWEET POTATOES. U. S. Dept. Agr. Bull. 1021, 30 pp., illus.
(47) Thurber, F. H.
1933. CHEMICAL AND PHYSICAL PROPERTIES OF SWEETPOTATO STARCH. Indus. and Engin. Chem. 25: 565–568.
(48) ———
1933. IMPROVED METHOD FOR PRODUCTION OF SWEETPOTATO STARCH. Indus. and Engin. Chem. 25: 919–920.
(49) ——— and Paine, H. S.
1934. THE PURIFICATION OF SWEET AND WHITE POTATO STARCHES. Indus. and Engin. Chem. 26: 567–569.
(50) Tiemann, Harry D.
1917. THE THEORY OF DRYING AND ITS APPLICATION TO THE NEW HUMIDITY-REGULATED AND RECIRCULATING DRY KILN. U. S. Dept. Agr. Bull. 509, 28 pp., illus.
(51) Wiegand, Ernest H.
1923. RECIRCULATION DRIERS. Oreg. Agr. Expt. Sta. Cir. 40, 11 pp., illus.

## ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

---

| | |
|---|---|
| *Secretary of Agriculture* | Henry A. Wallace. |
| *Under Secretary* | M. L. Wilson. |
| *Assistant Secretary* | Harry L. Brown. |
| *Coordinator of Land Use Planning and Director of Information* | M. S. Eisenhower. |
| *Director of Extension Work* | C. W. Warburton. |
| *Director of Finance* | W. A. Jump. |
| *Director of Personnel* | Roy F. Hendrickson. |
| *Director of Research* | James T. Jardine. |
| *Solicitor* | Mastin G. White. |
| *Agricultural Adjustment Administration* | H. R. Tolley, *Administrator.* |
| *Bureau of Agricultural Economics* | A. G. Black, *Chief.* |
| *Bureau of Agricultural Engineering* | S. H. McCrory, *Chief.* |
| *Bureau of Animal Industry* | John R. Mohler, *Chief.* |
| *Bureau of Biological Survey* | Ira N. Gabrielson, *Chief.* |
| *Bureau of Chemistry and Soils* | Henry G. Knight, *Chief.* |
| *Commodity Exchange Administration* | J. W. T. Duvel, *Chief.* |
| *Bureau of Dairy Industry* | O. E. Reed, *Chief.* |
| *Bureau of Entomology and Plant Quarantine.* | Lee A. Strong, *Chief.* |
| *Office of Experiment Stations* | James T. Jardine, *Chief.* |
| *Farm Security Administration* | W. W. Alexander, *Administrator.* |
| *Food and Drug Administration* | Walter G. Campbell, *Chief.* |
| *Forest Service* | Ferdinand A. Silcox, *Chief.* |
| *Bureau of Home Economics* | Louise Stanley, *Chief.* |
| *Library* | Claribel R. Barnett, *Librarian.* |
| *Bureau of Plant Industry* | E. C. Auchter, *Chief.* |
| *Bureau of Public Roads* | Thomas H. MacDonald, *Chief.* |
| *Soil Conservation Service* | H. H. Bennett, *Chief.* |
| *Weather Bureau* | C. C. Clark, *Acting Chief.* |

This circular is a contribution from

| | |
|---|---|
| *Bureau of Plant Industry* | E. C. Auchter, *Chief.* |
| *Division of Fruit and Vegetable Crops and Diseases* | H. P. Gould, *Principal Horticulturist, in Charge.* |

U. S. GOVERNMENT PRINTING OFFICE: 1938

---

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 10 cents